Exercise-1 (Topicwise)

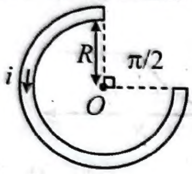
BIOT SAVART LAW

1. The magnetic field $d\vec{B}$ due to a small current element $d\vec{l}$ at a distance $\vec{r}$ and carrying current i is

(a) $d\vec{B}=\frac{\mu_0}{4\pi}i\left(\frac{d\vec{l}\times\vec{r}}{r}\right)$ (b) $d\vec{B}=\frac{\mu_0}{4\pi}i^2\left(\frac{d\vec{l}\times\vec{r}}{r}\right)$

(c) $d\vec{B}=\frac{\mu_0}{4\pi}i^2\left(\frac{d\vec{l}\times\vec{r}}{r^2}\right)$ (d) $d\vec{B}=\frac{\mu_0}{4\pi}i\left(\frac{d\vec{l}\times\vec{r}}{r^3}\right)$

2. A current i ampere flows in a circular arc of wire whose radius is R, which subtends an angle $3\pi/2$ radian at its center. The magnetic induction B at the center is



(a) $\frac{\mu_0 i}{R}$ (b) $\frac{\mu_0 i}{2R}$

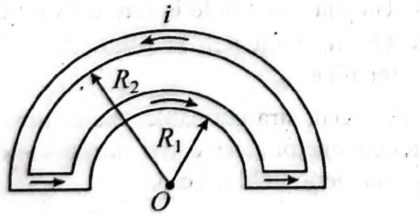
(c) $\frac{2\mu_0 i}{R}$ (d) $\frac{3\mu_0 i}{8R}$

3. A helium nucleus makes a full rotation in a circle of radius 0.8 metre in two seconds. The value of the magnetic field B at the center of the circle will be

(a) $\frac{10^{-19}}{\mu_0}$ (b) $10^{-19}\,\mu_0$

(c) $2\times10^{-10}\mu_0$ (d) $\frac{2\times10^{-10}}{\mu_0}$

4. The magnetic induction at the center O in the figure shown is



(a) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ (b) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$

(c) $\frac{\mu_0 i}{4}(R_1-R_2)$ (d) $\frac{\mu_0 i}{4}(R_1+R_2)$

5. A battery is connected between two points A and B on the circumference of a uniform conducting ring of radius r and resistance R. One of the arcs AB of the ring subtends an angle θ at the center. The value of the magnetic induction at the center due to the current in the ring is

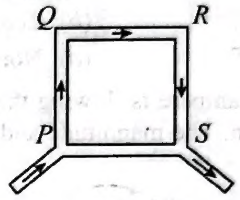
(a) Proportional to $2(180°-\theta)$

(b) Inversely proportional to r

(c) Zero, only if $\theta = 180°$

(d) Zero for all values of θ

6. $PQRS$ is a square loop made of uniform conducting wire the current enters the loop at P and leaves at S. Then the magnetic field will be



(a) Maximum at the center of the loop.

(b) Zero at the center of loop.

(c) Zero at all points inside the loop.

(d) Zero at all points outside of the loop.

7. A point charge is moving in a circle with constant speed. Consider the magnetic field produced by the charge at a fixed point P (not center of the circle) on the axis of the circle.

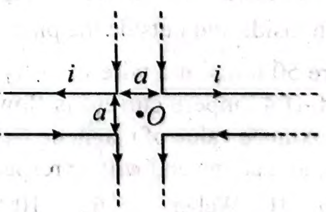
(a) It is constant in magnitude only.

(b) It is constant in direction only.

(c) It is constant in direction and magnitude both.

(d) It is not constant in magnitude and direction both.

8. Four infinitely long 'L' shaped wires, each carrying a current i have been arranged as shown in the figure. Obtain the magnetic field intensity at the point 'O' equidistant from all the four corners.



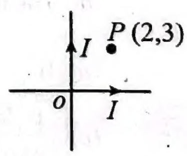
(a) 1 Wb/m^2 (b) 0 Wb/m^2

(c) 2 Wb/m^2 (d) None of these

9. Two mutually perpendicular insulated long conducting wires carrying equal currents I, interact at origin. Then the resultant magnetic induction at point P (2m, 3m) will be

(a) $\frac{\mu_0 I}{5a}$ (b) $\frac{5\mu_0 I}{2\pi}$

(c) $\frac{\mu_0 I}{12\pi}$ (d) 0



10. Two parallel straight long conducting wires, which are placed at a distance r from each other, are carrying equal currents i in opposite directions. The value of magnetic induction at a point situated at a point situated x from one wire in between the wires will be

(a) $\frac{\mu_0 i}{2\pi}\left\{\frac{1}{r-x}-\frac{1}{x}\right\}$ (b) $\frac{\mu_0 i}{2\pi}\left\{\frac{1}{r-x}+\frac{1}{x}\right\}$

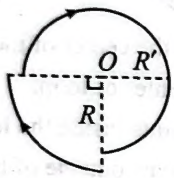
(c) $\frac{\mu_0 i}{2\pi(r-x)}$ (d) $\frac{\mu_0 i}{2\pi x}$

11. Two circular coils of wire each having a radius of 4 cm and 10 turns have a common axis and are 6 cm apart. If a current of 1 A passess through each coil in the opposite direction find the magnetic induction at a point on the axis, midway between them.

(a) 13×10^{-5} T (b) Zero

(c) 15×10^{-5} T (d) None of these

12. A current of i ampere is flowing through each of the bent wires as shown. The magnitude and direction of magnetic field at O is



(a) $\frac{\mu_0 i}{4}\left(\frac{1}{R}+\frac{2}{R'}\right)$ (b) $\frac{\mu_0 i}{4}\left(\frac{1}{R}+\frac{3}{R'}\right)$

(c) $\frac{\mu_0 i}{8}\left(\frac{1}{R}+\frac{3}{2R'}\right)$ (d) $\frac{\mu_0 i}{8}\left(\frac{1}{R}+\frac{3}{R'}\right)$

AMPERE'S LAW AND ITS APPLICATIONS

13. If a long hollow copper pipe carries a direct current, the magnetic field associated with the current will be

(a) Only inside the pipe.
(b) Only outside the pipe.
(c) Neither inside nor outside the pipe.
(d) Both inside and outside the pipe.

14. There are 50 turns of a wire in every cm length of a long solenoid. If 4 ampere current is flowing in the solenoid, the approximate value of magnetic field along its axis at an internal point at one end will be respectively

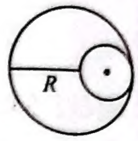
(a) 12.6×10^{-3} Weber / m^2, 6.3×10^{-3} Weber /m^2
(b) $2.6 \times 10^{-}$ Weber / m^2, 25.1×10^{-3} Weber /m^2
(c) 25.1×10^{-3} Weber / m^2, 12.6×10^{-3} Weber /m^2
(d) 25.1×10^{-5} Weber / m^2, 12.6×10^{-5} Weber /m^2

15. Current I is uniformly distributed across cross-section of thick hollow wire of internal radius 'a' and external radius 'b'. The magnetic field at $x < a$ (where x is radial distance)

(a) 0 (b) $\frac{\mu_0 I}{2\pi x}$

(c) $\frac{\mu_0 I x}{2\pi a^2}$ (d) $\frac{\mu_0 I x}{2\pi b^2}$

16. A long cylindrical wire of radius 'R' carries current along the axis. The current is uniformly distributed across cross-section having current density J. The wire contains a cylindrical cavity as shown in figure. Find the magnetic field at centre of the cavity

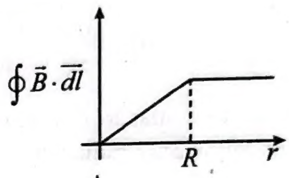


(a) Zero (b) $\mu_0 JR$

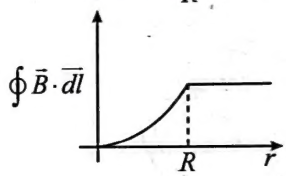
(c) $\frac{\mu_0 JR}{4}$ (d) $2\mu_0 JR$

17. A cylindrical wire of radius R is carrying current i uniformly distributed over its cross-section. If a circular loop of radius 'r' is taken as amperian loop, then the variation value of $\oint \vec{B}\cdot\vec{d\ell}$ over this loop with radius 'r' of loop will be best represented by

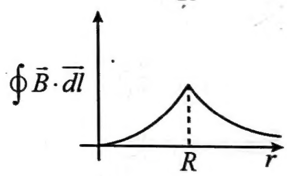
(a)



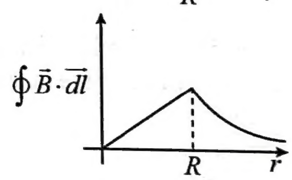
(b)



(c)



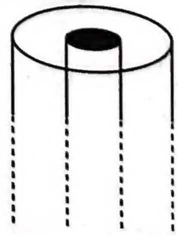
(d)



18. A current I flows along the length of an infinitely long, straight, thin walled pipe. Then

(a) The magnetic field at all points inside the pipe is the same, but not zero.
(b) The magnetic field at any point inside the pipe is zero.
(c) The magnetic field is zero only on the axis of the pipe.
(d) The magnetic field is different at different points inside the pipe.

19. In a coaxial, straight cable, the central conductor and the outer conductor carry equal currents in opposite directions. The magnetic field is zero.



(a) Outside the cable.
(b) Inside the inner conductor.
(c) Inside the outer conductor.
(d) In between the two conductors.

MOTION OF CHARGED PARTICLE IN MAGNETIC FIELD

20. A uniform electric field and a uniform magnetic field are produced, pointed in the same direction. An electron is projected with its velocity pointing in the same direction

(*a*) The electron will turn to its right.

(*b*) The electron will turn to its left.

(*c*) The electron velocity will increase in magnitude.

(*d*) The electron velocity will decrease in magnitude.

21. An electron moving with a velocity of 10^6 m /s, enters a region where magnetic field exists. If it describes a circle of radius 0.10 m, the intensity of magnetic field must be

(*a*) 1.8×10^{-4} T (*b*) 5.6×10^{-5} T

(*c*) 14.4×10^{-5} T (*d*) 1.3×10^{-6} T

22. A proton is moving along *Z*-axis in a magnetic field. The magnetic field is along *X*-axis. The proton will experience a force along

(*a*) *X*-axis (*b*) *Y*-axis

(*c*) *Z*-axis (*d*) Negative *Z*-axis

23. A deutron of kinetic energy 50 keV is describing a circular orbit of radius 0.5 metre in a plane perpendicular to magnetic field $\vec{B}$. The kinetic energy of the proton that describes a circular orbit of radius 0.5 metre in the same lane with the same $\vec{B}$ is

(*a*) 25 keV (*b*) 50 keV

(*c*) 200 keV (*d*) 100 keV

24. The charge on a particle *Y* is double the charge on particle *X*. These two particles *X* and *Y* after being accelerated through the same potential difference enter a region of uniform magnetic field and describe circular paths of radii R_1 and R_2 respectively. The ratio of the mass of *X* to that of *Y* is

(*a*) $\left(\frac{2R_1}{R_2}\right)^2$ (*b*) $\left(\frac{R_1}{2R_2}\right)^2$

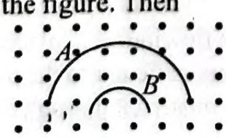
(*c*) $\frac{R_1^2}{2R_2^2}$ (*d*) $\frac{2R_1}{R_2}$

25. A charged particle enters a magnetic field *B* with its initial velocity making an angle of 45° with *B*. The path of the particle will be

(*a*) A straight line (*b*) A circle

(*c*) An ellipse (*d*) A helix

26. Two particles *A* and *B* of masses m_A and m_B respectively and having the same charge are moving in a plane. A uniform magnetic field exists perpendicular to this plane. The speeds of the particles are v_A and v_B respectively, and the trajectories are as shown in the figure. Then



(*a*) $m_A v_A < m_B v_B$ (*b*) $m_A v_A > m_B v_B$

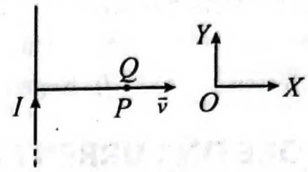
(*c*) $m_A < m_B$ and $v_A < v_B$ (*d*) $m_A = m_B$ and $v_A = v_B$

27. A particle of mass *M* and charge *Q* moving with velocity describes a circular path of radius *R* when subjected to a uniform transverse magnetic field of induction *B*. The work done by the field when the particle completes one full circle is

(*a*) $BQv\, 2\pi R$ (*b*) $\left(\frac{Mv^2}{R}\right)2\pi R$

(*c*) Zero (*d*) $BQ2\pi R$

28. A very long straight wire carries a current *I*. At the instant when a charge +*Q* at point *P* has velocity $\vec{v}$, as shown, the force on the charge is



(*a*) Opposite to *OX* (*b*) Along *OX*

(*c*) Opposite to *OY* (*d*) Along *OY*

29. A negative charged particle falling freely under gravity enters a region having uniform horizontal magnetic field pointing towards north. The particle will be deflected towards

(*a*) East (*b*) West

(*c*) North (*d*) South

30. A positively charged particle moves in a region having a uniform magnetic field and uniform electric field in same direction. At some instant, the velocity of the particle is perpendicular to the field direction. The path of the particle will be

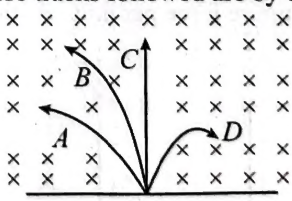
(*a*) A straight line.

(*b*) A circle.

(*c*) A helix with uniform pitch.

(*d*) A helix with increasing pitch.

31. A neutron, a proton, an electron and an α-particle enters a uniform magnetic field with equal velocities. The field is directed along the inward normal to the plane of the paper. Which of these tracks followed are by α-particle?



(*a*) *A* (*b*) *B*

(*c*) *C* (*d*) *D*

32. Electrons moving with different speeds enter a uniform magnetic field in a direction perpendicular to the field. They will move along circular paths.

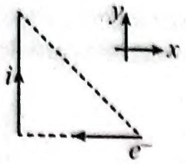
(*a*) Of same radius.

(*b*) With larger radii for the faster electrons.

(*c*) With smaller radii for the faster electrons.

(*d*) Either (*b*) or (*c*) depending on the magnitude of the magnetic field.

33. The direction of magnetic force on the electron as shown in the diagram is along



(*a*) y-axis (*b*) $-y$-axis

(c) z-axis (*d*) $-z$-axis

34. An electron is moving along positive x-axis. A uniform electric field exists towards negative y-axis. What should be the direction of magnetic field of suitable magnitude so that net force of electron is zero?

(*a*) Positive z-axis (*b*) Negative z-axis

(c) Positive y-axis (*d*) Negative y-axis

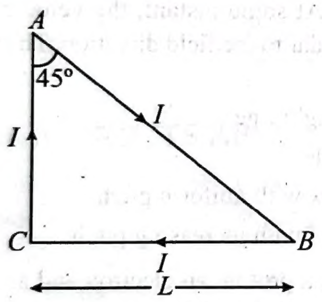
MAGNETIC FORE ON CURRENT CARRYING WIRE

35. Two long and parallel wires are at a distance of 0.1 m and a current of 5 A is flowing in each of these wires. The force per unit length due to these wires will be

(*a*) 5×10^{-5} N/m (*b*) 5×10^{-3} N/m

(c) 2.5×10^{-5} N/m (*d*) 2.5×10^{-4} N/m

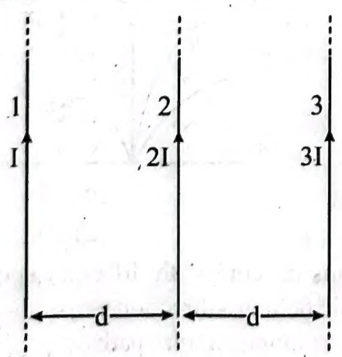
36. A uniform magnetic field exist in a region . A loop carrying current is placed in this magnetic field as shown in figure, then force on loop ABC is



(*a*) BIL (*b*) 3 BIL

(c) $(2+\sqrt{2})BIL$ (*d*) Zero

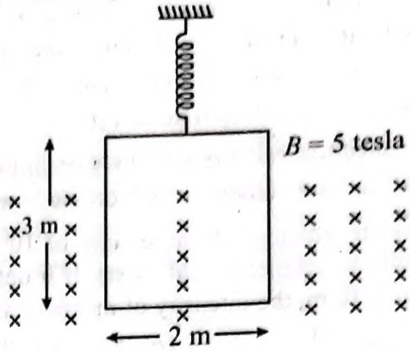
37. In the given figure force per unit length on wire 2 will be



(*a*) $\frac{2\mu_0 I^2}{\pi d}$(left) (*b*) $\frac{2\mu_0 I^2}{\pi d}$(Right)

(c) $\frac{\mu_0 I^2}{\pi d}$(left) (*d*) $\frac{\mu_0 I^2}{\pi d}$(Right)

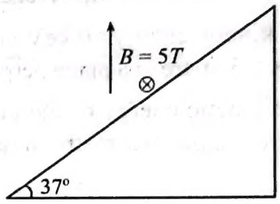
38. The mass per unit length of wire is 2 kg/m and spring constant of spring is 100 N/m. The magnitude and direction of current in wire so that the spring force becomes zero. (Take $g = 10$ m/s^2)



(*a*) 4 A clockwise (*b*) 4 A anticlockwise

(c) 10 A anticlockwise (*d*) 20 A anticlockwise

39. A smooth incline plane is placed in uniform magnetic field. A wire of length 1 m and 1 kg is placed on incline plane. The current in wire is 2 A and its direction is shown in figure. What is normal reaction force on wire?



(*a*) Zero (*b*) 8 Newton

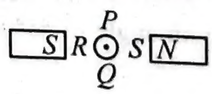
(c) 14 Newton (*d*) 12 Newton

40. In the previous question if inclined plane is rough and current in wire is doubled, then the magnitude of fiction on wire to keep wire at rest is :

(*a*) 10 Newton (*b*) 8 Newton

(c) 12 Newton (*d*) 16 Newton

41. A straight current carrying conductor is placed in such a way that the current in the conductor flows in the direction out of the plane of the paper. The conductor is placed between two poles of two magnets, as shown. The conductor will experience a force in the direction towards



(*a*) P (*b*) Q

(c) R (*d*) S

TORQUE AND POTENTIAL ENERGY OF COIL IN EXTERNAL MAGNETIC FIELD

42. A circular coil of radius 4 cm has 50 turns. In this coil a current of 2 A is flowing. It is placed in a magnetic field of 0.1 weber/m^2 perpendicular to the plane of coil. The amount of work done in rotating it through 180° from its equilibrium position will be

(*a*) 0.1 J (*b*) 0.2 J (c) 0.4 J (*d*) 0.8 J

43. The radius of a circular loop is r and a current i is flowing in it. The equivalent magnetic moment will be

(a) ir (b) $2\pi ir$

(c) $i\pi r^2$ (d) $\frac{1}{r^2}$

44. To make the field radial in a moving coil galvanometer

(a) The number of turns in the coil is increased.

(b) Magnet is taken in the form of horse-shoe.

(c) Poles are cylindrically cut.

(d) Coil is wounded on aluminium frame.

45. In a moving coil galvanometer, the deflection of the coil is related to the electrical current i by the relation

(a) $i \propto \tan\theta$ (b) $i \propto \theta$

(c) $i \propto \theta^2$ (d) $i \propto \sqrt{\theta}$

46. A small coil of N turns has an effective area A and carries a current I. It is suspended in a horizontal magnetic field $\vec{B}$ such that its plane is perpendicular to $\vec{B}$. The work done in rotating it by 180° about the vertical axis is

(a) $NAIB$ (b) $2NAIB$

(c) $2\pi NAIB$ (d) $4\pi NAIB$

47. A triangular loop of side l carries a current I. It is placed in a magnetic field B such that the plane of the loop is in the direction of B. The torque on the loop is

(a) Zero (b) IBl

(c) $\frac{\sqrt{3}}{2}Il^2B^2$ (d) $\frac{\sqrt{3}}{4}Il^2B$

48. A circular loop of area 1 cm², carrying a current of 10 A, is placed in a magnetic field of 0.1 T perpendicular to the plane of the loop. The torque on the loop due to the magnetic field is

(a) Zero (b) 10^{-4} Nm

(c) 10^{-2} Nm (d) 1 Nm

49. A small circular loop of conducting wire has radius a and carries current I. It is placed in a uniform magnetic field B perpendicular to its plane such that when rotated slightly about its diameter and released, it starts performing simple harmonic motion of time period T. If the mass of the loop is m then

(a) $T=\sqrt{\frac{\pi m}{IB}}$ (b) $T=\sqrt{\frac{2m}{IB}}$

(c) $T=\sqrt{\frac{\pi m}{2IB}}$ (d) $T=\sqrt{\frac{2\pi m}{IB}}$

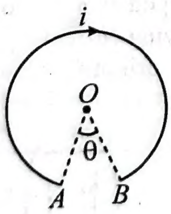
Exercise-2 (Learning Plus)

1. Two parallel, long wires carry currents i_1 and i_2 with $i_1 > i_2$. When the current are in the same direction, the magnetic field at a point midway between the wire is 20 μT. If the direction of i_1 is reversed, the field becomes 30 μT. The ratio i_1/i_2 is

(a) 4 (b) 3

(c) 5 (d) 1

2. A current carrying wire AB of the length $2\pi R$ is turned along a circle, as shown in figure. The magnetic field at the centre O.



(a) $\frac{\mu_0 i}{2R}\left(\frac{2\pi-\theta}{2\pi}\right)^2$ (b) $\frac{\mu_0 i}{2R}\left(\frac{2\pi-\theta}{2\pi}\right)$

(c) $\frac{\mu_0 i}{2R}(\pi-\theta)$ (d) $\frac{\mu_0 i}{2R}(2\pi+\theta)^2$

3. Electric current i enters and leaves a square loop made of homogeneous wire of uniform cross-section through diagonally opposite corners. A charge particle q moving along the axis of the square loop passes through centre at speed v. The magnetic force acting on the particle when it passes through the centre has a magnitude

(a) $qv\frac{\mu_0 i}{2a}$ (b) $qv\frac{\mu_0 i}{2\pi a}$

(c) $qv\frac{\mu_0 i}{a}$ (d) zero

4. A particle having charge of 1 C, mass 1 kg and speed 1 m/s enters a uniform magnetic field, having magnetic induction of 1 T, at an angle θ = 30° between velocity vector and magnetic induction. The pitch of its helical path is (in meters)

(a) $\frac{\sqrt{3}\pi}{2}$ (b) $\sqrt{3}\pi$

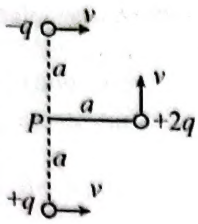
(c) $\frac{\pi}{2}$ (d) π.

5. Two infinitely long, thin, insulated, straight wires lie in the x-y plane along the x and y-axis respectively. Each wire carries a current I, respectively in the positive x-direction and positive y-direction. The magnetic field will be zero at all points on the straight line:

(a) $y=x$ (b) $y=-x$

(c) $y=x-1$ (d) $y=-x+1$

6. A charge $+2q$ moves vertically upwards with speed v, a second charge $-q$ moves horizontally to the right with the same speed v, and a third charge $+q$ moves horizontally to the right with the same speed v. The point P is located a perpendicular distance a away from each charge as shown in the figure. The magnetic field at point P is



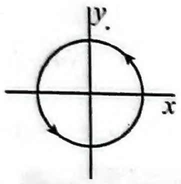
(a) Into the page with magnitude $\frac{\mu_0}{4\pi}\frac{2qv}{a^2}$.

(b) Into the page with magnitude $\frac{\mu_0}{4\pi}\frac{4qv}{a^2}$.

(c) Out of the page with magnitude $\frac{\mu_0}{4\pi}\frac{2qv}{a^2}$.

(d) Out the page with magnitude $\frac{\mu_0}{4\pi}\frac{4qv}{a^2}$.

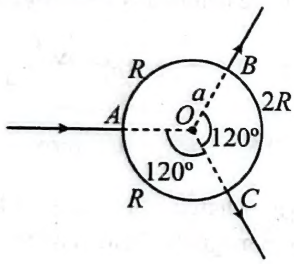
7. Current $i = 2.5$ A flows along the circle $x^2 + y^2 = 9$ cm^2 (here x and y are in cm) as shown. Magnetic field (in Tesla) at point (0, 0, 4 cm) is



(a) $(36\pi \times 10^{-7})\hat{k}$ (b) $(36\pi\times10^{-7})(-\hat{k})$

(c) $\left(\frac{9\pi}{5}\times10^{-7}\right)\hat{k}$ (d) $\left(\frac{9\pi}{5}\times10^{-7}\right)(-\hat{k})$

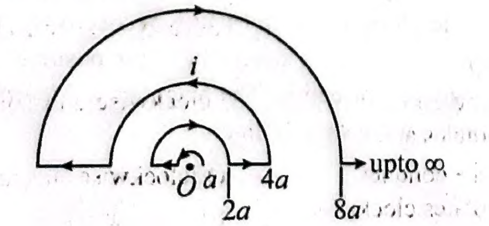
8. The resistances of three parts of a circular loop are as shown in the figure. The magnetic field at the centre O is



(a) $\frac{\mu_0 I}{6a}$ (b) $\frac{\mu_0 I}{3a}$

(c) $\frac{2}{3}\frac{\mu_0 I}{a}$ (d) Zero

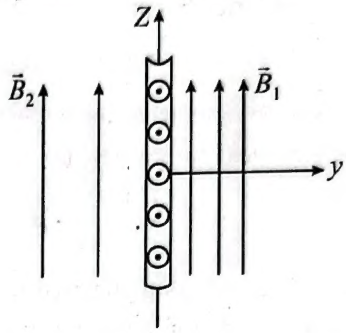
9. A conductor carrying current 'i' is bent in the form of concentric semicircles as shown in the figure. The magnetic field at the centre O is :



(a) Zero (b) $\frac{\mu_0 i}{6a}$

(c) $\frac{\mu_0 i}{a}$ (d) $\frac{\mu_0 i \ln 2}{4a}$

10. Figure shows a thin metal sheet in the plane $y = 0$, for which the current of constant density flows in the positive x-direction. It is in a constant homogeneous magnetic field of value $= (0, 0, B_0)$. As a result of superposition of magnetic fields in region $y > 0$, the induction field $B_1 = (0, 0, B)$ and in $y < 0$ is $B_2 = (0, 0, B_2)$ where $B_1 > B_2$. Specify the correct statement:



(a) $B_0 = \frac{(B_1 - B_2)}{2}$ (b) $B_0 = \frac{(B_1 + B_2)}{2}$

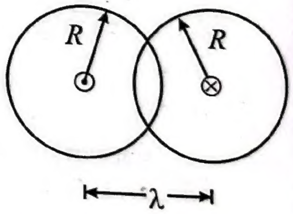
(c) $B_0 = B_1 + B_2$ (d) $B_0 = B_1 - B_2$

11. Three long current carrying wires are placed such that their current is in positive z direction. They are parallel to z axis and pass through the point (3,0,0), (–3,0,0) and (0,0,0). The current in all the three wires are equal. Find the coordinates of the point where the magnetic field is zero.

(a) $(\sqrt{3}, 0, 1)$ (b) (2, 1, 0)

(c) (0, 1, 2) (d) (2, 0, 2)

12. Two cylindrical conductors carrying same current but in the opposite direction to each other as shown. The current density in both of them is J. What is the magnetic field in the overlapping region ?



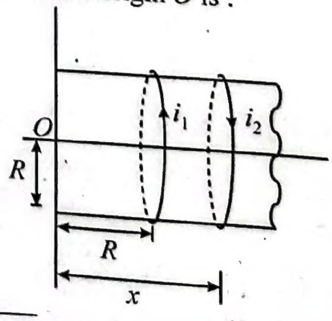
(a) $\frac{\mu_0 \vec{J} \times \vec{\ell}}{2}$

(b) $\mu_0(\vec{J} \times \vec{\ell})$

(c) Different at different points

(d) $2\mu_0(\vec{J} \times \vec{\ell})$

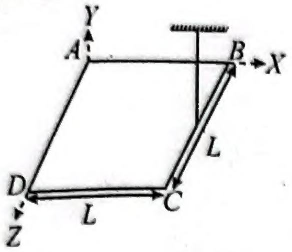
13. Two wires are wrapped over a wooden cylinder to form two co-axial loops carrying currents i_1 and i_2. if $i_2 = 8i_1$ the value of x for $B = 0$ at the origin O is :



(a) $\sqrt{(\sqrt{7}-1)R}$ (b) $\sqrt{5}R$

(c) $\sqrt{3}R$ (d) $\sqrt{7}R$

14. A square loop of side L and mass M is hinged about edge AD and edge BC is attached with a string such that the loop is horizontal. A magnetic field is present along +ve x-axis. A current flows along $D \to A \to B \to C \to D$ such that the tension in the string becomes zero. If the direction of current is reversed by keeping magnitude same, the tension in the string will become



(*a*) Mg (*b*) $2Mg$

(*c*) $3Mg$ (*d*) $\dfrac{3Mg}{2}$

15. A conductor of length l is placed perpendicular to a horizontal uniform magnetic field B. Suddenly a certain amount of charge is passed through it, when it is found to jump to a height h. The amount of charge that passes through the conductor is

(*a*) $\dfrac{m\sqrt{gh}}{Bl}$ (*b*) $\dfrac{2m\sqrt{gh}}{3Bl}$

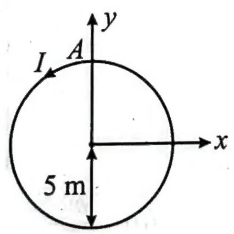
(*c*) $\dfrac{m\sqrt{2gh}}{Bl}$ (*d*) None of the above

16. Co-ordinates of four corners of a square loop are $A \equiv (0, 0, 0)$, $B \equiv (0, 0, a)$, $C \equiv \left(\dfrac{a}{\sqrt{2}}, \dfrac{a}{\sqrt{2}}, a\right)$ and $D \equiv \left(\dfrac{a}{\sqrt{2}}, \dfrac{a}{\sqrt{2}}, 0\right)$. A current I is flowing in the loop in $ABCDA$ direction. The magnetic moment of the loop would be

(*a*) $\left(\dfrac{a^2}{\sqrt{2}}\hat{j} + \dfrac{a^2}{\sqrt{2}}\hat{k}\right)I$ (*b*) $\left(\dfrac{a^2}{\sqrt{2}}\hat{j} - \dfrac{a^2}{\sqrt{2}}\hat{i}\right)I$

(*c*) $\left(\dfrac{a^2}{\sqrt{2}}\hat{j} + \dfrac{a^2}{\sqrt{2}}\hat{i}\right)I$ (*d*) $\left(\dfrac{a^2}{\sqrt{2}}\hat{i} - \dfrac{a^2}{\sqrt{2}}\hat{j}\right)I$

17. A ring of radius 5 m is lying in the x-y plane and is carrying current of 1 A in anti-clockwise sense. If a uniform magnetic field $\vec{B} = 3\hat{i} + 4\hat{j}$ is switched on, then the co-ordinates of point about which the loop will lift up is:



(*a*) (3, 4) (*b*) (4, 3)

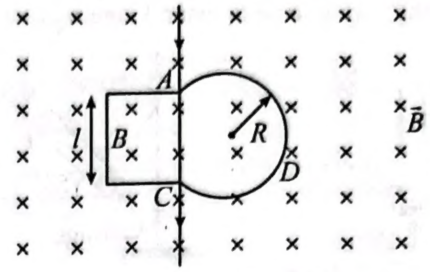
(*c*) (3, 0) (*d*) (–3, –4)

18. A circular coil of 100 turns and effective diameter 20 cm carries a current of 0.5 A. It is to be turned in a magnetic field $B = 2$ T from a position in which θ equals zero to θ equals 180°. The work required in this process is

(*a*) π J (*b*) 2π J

(*c*) 4π J (*d*) 8π J

19. The figure shows a conducting loop $ABCDA$ placed in a uniform magnetic field perpendicular to its plane. The part ABC is the $(3/4)^{th}$ portion of the square of side length l. The part ADC is a circular arc of radius R. The points A and C are connected to a battery which supply a current I to the circuit. The magnetic force on the loop due to the field B is



(*a*) Zero (*b*) BIl

(*c*) $2BIR$ (*d*) $\dfrac{BIlR}{l+R}$

20. A very long wire carrying current I is fixed along x-axis. Another parallel finite wire carrying a current in the opposite direction is kept at a distance d above the wire in xy plane. The second wire is free to move parallel to itself. The options available for its small displacements are in

(i) +ve x direction (ii) +ve y direction

(iii) +ve z direction

Taking gravity in negative y direction, the nature of equilibrium of second wire is

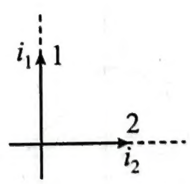
(*a*) Stable for movement in x direction, unstable for movement in y direction, neutral for movement in z direction.

(*b*) Stable for movement in y direction, unstable for movement in z direction, neutral for movement in x direction.

(*c*) Stable for movement in z direction, unstable for movement in y direction, neutral for movement in x direction.

(*d*) Stable for movement in y direction, unstable for movement in x direction, neutral for movement in z direction.

21. Two rigid long wires carrying currents i_1 and i_2 are placed over each other. Then under influence of each other's magnetic field,



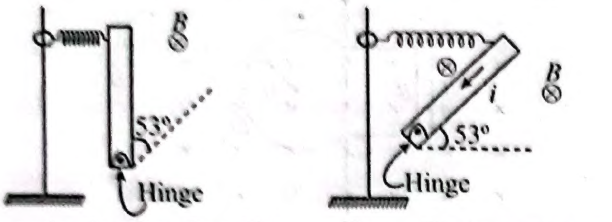
(*a*) The conductor 1 slides to right and conductor 2 slides downwards.

(*b*) The conductor 1 slides to left and the conductor 2 slides up.

(*c*) The conductor 1 rotates clockwise and conductor 2 rotates anticlockwise.

(*d*) The conductor 1 rotates anticlockwise and conductor 2 rotates clockwise.

22. A thin uniform rod with negligible mass and length l is attached to the floor by a frictionless hinge at point P. A horizontal spring with force constant k connects the other end to wall. The rod is in a uniform magnetic field B directed into the plane of paper. What is extension in spring in equilibrium when a current is passed through the rod in direction shown? (Assuming spring to be in natural length initially.)

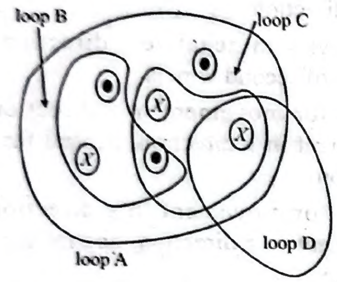


spring in relaxed position   In equilibrium position

(a) $\frac{5ilB}{8k}$ (b) $\frac{3ilB}{8k}$

(c) $\frac{5ilB}{4k}$ (d) $\frac{5ilB}{6k}$

23. Consider six wires coming into or out of the page, all with the same current. Rank the line integral of the magnetic field (from most positive to most negative) taken counterclockwise around each loop shown.



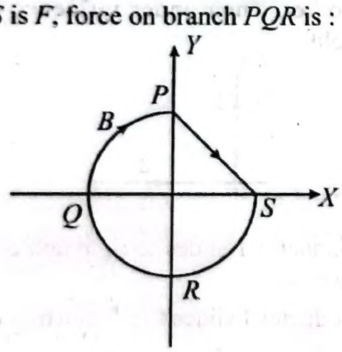
(a) B > C > D > A

(b) B > C = D > A

(c) B > A > C = D

(d) C > B = D > A

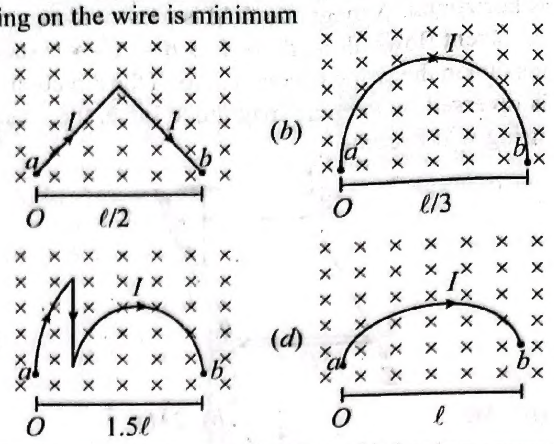
24. A current carrying loop is placed in a uniform magnetic field pointing in negative z direction. Branch $PQRS$ is a three quarter circle, while branch PS is straight. If force on branch PS is F, force on branch PQR is :



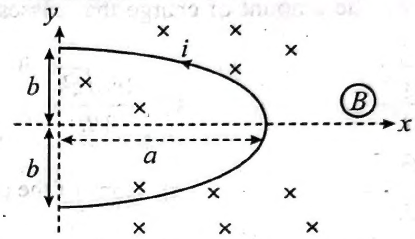
(a) $\sqrt{2}F$ (b) $\frac{F}{\sqrt{2}}$

(c) $\frac{\pi F}{\sqrt{2}}$ (d) $\sqrt{2}\pi F$

25. Figure shows four wires placed in the same uniform magnetic field B and carrying the same current in which case force acting on the wire is minimum



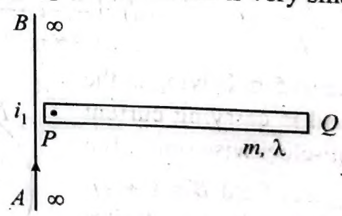
26. In the figure, there is a conducting wire having current i and which has a shape of half ellipse $\left[\frac{x^2}{a^2}+\frac{y^2}{b^2}=1\right]$ is kept in a uniform magnetic field B as shown. If the mass of wire is m, the acceleration of wire will be



(a) $\frac{ibB}{m}$ (b) $\frac{iaB}{m}$

(c) $\frac{2iaB}{m}$ (d) $\frac{2ibB}{m}$

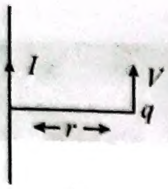
27. A metallic rod PQ is hinged at point P and it can rotate about point P in vertical plane as shown in the figure. If mass of rod is m and length l, then the current in PQ, such that it remains in equilibrium as shown. (Separation between P and current carrying conductor AB is very small)



(a) $\frac{2mg\pi}{\mu_0 i_1}$ (b) $\frac{mg\pi}{2\mu_0 i_1}$

(c) $\frac{mg\pi}{4\mu_0 i_1}$ (d) $\frac{mg\pi}{\mu_0 i_1}$

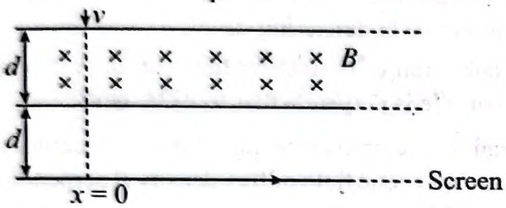
28. A particle with charge 'q' is travelling with velocity 'v' parallel to a wire with a uniform linear charge distribution λ per unit length. The wire also carries a current I as shown in the fig. The velocity with which particle travels in a straight line parallel to the wire at a distance 'r' away is (c = speed of light in medium)



(a) $\dfrac{\lambda}{\mu\varepsilon I}$ (b) $\dfrac{\lambda}{2\mu\varepsilon I}$

(c) $\dfrac{\lambda c^2}{I}$ (d) $\dfrac{2\lambda}{\mu\varepsilon I}$

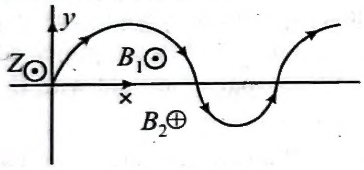
29. A non relativistic positive charge particle of charge q and mass m is projected perpendicular to uniform magnetic field B as shown. Neglecting gravity calculate X-coordinate of point on screen at which the charge particle will hit: $d = \dfrac{r\sqrt{3}}{2}$, where $r = \dfrac{mv}{qB}$



(a) $\sqrt{3}r$ (b) $2r$

(c) $2.5r$ (d) $0.5r$

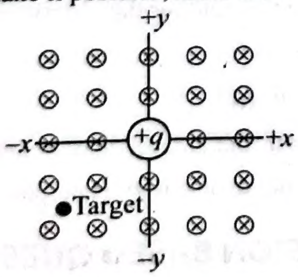
30. At $t = 0$ a charge q is at the origin and moving in the y-direction with velocity $\vec{v} = v\hat{j}$. The charge moves in a magnetic field that is for $y > 0$ out of page and given by $B_1\hat{z}$ and for $y < 0$ into the page and given $-B_2\hat{z}$. The charge's subsequent trajectory is shown in the sketch. From this information, we can deduce that



(a) $q > 0$ and $|B_1| < |B_2|$ (b) $q < 0$ and $|B_1| < |B_2|$

(c) $q > 0$ and $|B_1| > |B_2|$ (d) $q < 0$ and $|B_1| > |B_2|$

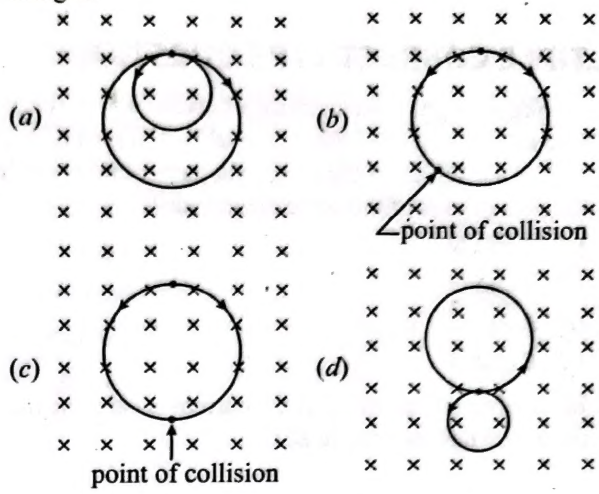
31. The figure shows a particle (carrying charge $+q$) at the origin. A uniform magnetic field is directed into the plane of the paper. The particle can be projected only in the plane of paper and along positive or negative x- or y-axis. The particle moves with constant speed and has to hit a target located in the third quadrant. There are two direction of projections, which can make it possible, these are



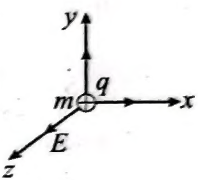
(a) $+x$ and $+y$ (b) $+x$ and $-y$

(c) $-x$ and $+y$ (d) $-x$ and $-y$

32. A neutral particle at rest in a magnetic field decays into two charged particles of different mass. The energy released goes into their kinetic energy. Then what can be the path of the two particles. Neglect any interaction between the two charges.



33. A charge particle of charge q, mass m is projected with a velocity $\vec{v} = v\hat{i}$. The electric field $\vec{E} = E\hat{k}$ and magnetic field $\vec{B} = B\hat{j}$ is applied. The acceleration of the particle is



(a) $\dfrac{qvB}{m}\hat{k}$ (b) $\dfrac{qE}{m}\hat{k}$

(c) $\dfrac{q(E + vB)\hat{k}}{m}$ (d) $\dfrac{q(E - vB)\hat{k}}{m}$

34. A charge q is moving with a velocity $\vec{v}_1 = 1\hat{i}$ m/s at a point in a magnetic field and experiences a force $\vec{F}_1 = q[-\hat{j} + \hat{k}]$ N. If the charge is moving with a velocity $\vec{v}_2 = 1\hat{j}$ m/s at the same point, it experiences a force $\vec{F}_2 = q[\hat{i} - \hat{k}]$ N. The magnetic induction $\vec{B}$ at that point is

(a) $(\hat{i} + \hat{j} + \hat{k})\text{Wb/m}^2$ (b) $(\hat{i} - \hat{j} + \hat{k})\text{Wb/m}^2$

(c) $(-\hat{i} + \hat{j} - \hat{k})\text{Wb/m}^2$ (d) $(\hat{i} + \hat{j} - \hat{k})\text{Wb/m}^2$

35. Electric and magnetic field are directed as $E_0\hat{i}$ and $B_0\hat{k}$, a particle of mass m and charge $+q$ is released from position (0, 2, 0) from rest. The velocity of that particle at $(x, 5, 0)$ is $(5\hat{i} + 12\hat{j})$ the value of x will be

(a) $\dfrac{25m}{2qE_0}$ (b) $\dfrac{25m}{12qE_0}$

(c) $\dfrac{144m}{12qE_0}$ (d) $\dfrac{169m}{2qE_0}$

36. A charged particle is projected in a magnetic field $\vec{B} = 10\hat{k}$ T from the origin in x-y plane. The particle moves in a circle and just touches a straight line $y = 5$ (m) at $x = 5\sqrt{3}$ (m). Then (mass of particle $= 5 \times 10^{-5}$ kg, charge $= 1\,\mu$C)

(a) the coordinates of centre of circular path are (10, 0)

(b) the coordinates of centre of circular path are $(5\sqrt{3}, -5)$

(c) the coordinates of centre of circular path are $(5, -5\sqrt{3})$

(d) the coordinates of centre of circular path are $(5\sqrt{3}, -5/2)$

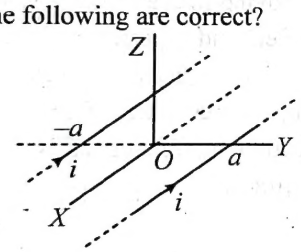
Exercise-3 (JEE Advanced Level)

MULTIPLE CORRECT TYPE QUESTIONS

1. A long straight wire carries a current along the x-axis. Consider the points $A(0, 1, 0)$, $B(0, 1, 1)$, $C(1, 0, 1)$ and $D(1, 1, 1)$. Which of the following pairs of points will have magnetic fields of the same magnitude?
   (a) A and B
   (b) A and C
   (c) B and C
   (d) B and D

2. In the previous question, if the current is i and the magnetic field at D has magnitude B, then
   (a) $B = \dfrac{\mu_0 i}{2\sqrt{2}\pi}$
   (b) $B = \dfrac{\mu_0 i}{2\sqrt{3}\pi}$
   (c) B is parallel to the x-axis.
   (d) B makes an angle of 45° with the xy plane.

3. Two long thin, parallel conductors carrying equal currents in the same direction are fixed parallel to the x-axis, one passing through $y = a$ and the other through $y = -a$. The resultant magnetic field due to the two conductors at any point is B. Which of the following are correct?



   (a) $B = 0$ for all points on the x-axis.
   (b) At all points on the y-axis, excluding the origin, B has only a z-component.
   (c) At all points on the z-axis, excluding the origin, B has only a y-component.
   (d) B cannot have an x-component.

4. A hollow tube is carrying an electric current along its length distributed uniformly over its surface. The magnetic field
   (a) Increase linearly from the axis to the surface.
   (b) Is constant inside the tube.
   (c) Is zero at the axis.
   (d) Is non-zero outside the tube at finite distance from surface.

5. Two identical charged particles enter a uniform magnetic field with same speed but at angles 30° and 60° with field. Let a, b and c be the ratio of their time periods, radii and pitches of the helical paths then
   (a) $abc = 1$
   (b) $abc > 1$
   (c) $abc < 1$
   (d) $a = bc$

6. Consider the following statements regarding a charged particle in a magnetic field. Which of the statements are true
   (a) Starting with zero velocity, it accelerates in a direction perpendicular to the magnetic field.
   (b) While deflecting in magnetic field its energy gradually increases.
   (c) Only the component of magnetic field perpendicular to the direction of motion of the charged particle is effective in deflecting it.
   (d) Direction of deflecting force on the moving charged particle is perpendicular to its velocity.

7. A beam of electrons moving with a momentum p enters a uniform magnetic field of flux density B perpendicular to its motion. Which of the following statement(s) is (are) true?
   (a) Energy gained is $\dfrac{p^2}{2m}$
   (b) Centripetal force on the electron is $Be\dfrac{m}{p}$
   (c) Radius of the electron's path is $\dfrac{p}{Be}$
   (d) Work done on the electrons by the magnetic field is zero.

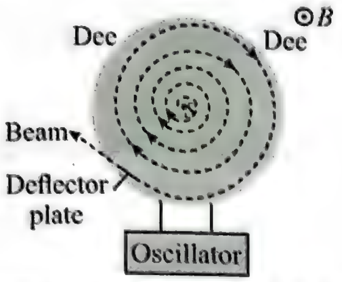
8. Two ions have equal masses but one is singly-ionized and other is tripply-ionized. They are projected from the same place in a uniform magnetic field with the same velocity perpendicular to the field.
   (a) Both ions will go along circles of equal radii.
   (b) The circle described by the single-ionized charge will have a radius triple that of the other circle.
   (c) The two circles do not touch each other.
   (d) The two circles touch each other.

9. Let $\vec{E}$ and $\vec{B}$ denote the electric and magnetic fields in a certain region of space. A proton moving with a velocity $\vec{v}$ along a straight line enters the region and is found to pass through it undeflected. Indicate which of the following statements are possible for the observation?
   (a) $\vec{E} = 0$ and $\vec{B} = 0$
   (b) $\vec{E} \neq 0$ and $\vec{B} = 0$
   (c) $\vec{E} \neq 0, \vec{B} \neq 0$ and both $\vec{E}$ and $\vec{B}$ are parallel to $\vec{v}$
   (d) $\vec{E}$ is parallel to $\vec{v}$ but $\vec{B}$ is perpendicular to $\vec{v}$

COMPREHENSION BASED QUESTIONS

Comprehension(Q. 10 to 14): (Read the following passage and answer the questions. They have only one correct option)

In the given figure of a cyclotron, showing the particle source S and the dees. A uniform magnetic field is directed up from the plane of the page. Circulating protons spiral outward within the hollow dees, gaining energy every time they cross the gap between the dees.



Suppose that a proton, injected by source S at the centre of the cyclotron in figure initially moves toward a negatively charged dee. It will accelerate toward this dee and enter it. Once inside, it is shielded from electric field by the copper walls of the dee; that is the electric field does not enter the dee. The magnetic field, however, is not screened by the (nonmagnetic) copper dee, so the proton moves in circular path whose radius, which depends on its speed, is given by

$$r = \frac{mv}{qB} \qquad \text{...(i)}$$

Let us assume that at the instant the proton emerges into the center gap from the first dee, the potential difference between the dees is reversed. Thus, the proton again faces a negatively charged dee and is again accelerated. This process continues, the circulating proton always being in step with the oscillations of the dee potential, until the proton has spiraled out to the edge of the dee system. There a deflector plate sends it out through a portal.

The key to the operation of the cyclotron is that the frequency f at which the proton circulates in the field (and that does not depend on its speed) must be equal to the fixed frequency f_{osc} of the electrical oscillator, or

$$f = f_{osc} \text{ (resonance condition)} \qquad \text{...(ii)}$$

This resonance condition says that if the energy of the circulating proton is to increase, energy must be fed to it at a frequency f_{osc} that is equal to the natural frequency f at which the proton circulates in the magnetic field.

Combining Eq. (i) and (ii) allows us to write the resonance condition as

$$qB = 2\pi m f_{osc}. \qquad \text{...(iii)}$$

For the proton, q and m are fixed. The oscillator (we assume) is designed to work at a single fixed frequency f_{osc}. We then "tune" the cyclotron by varying B until eq. (iii) is satisfied and then many protons circulate through the magnetic field, to emerge as a beam.

10. Ratio of radius of successive semi circular path is

(*a*) $\sqrt{1}:\sqrt{2}:\sqrt{3}:\sqrt{4}$

(*b*) $\sqrt{1}:\sqrt{3}:\sqrt{5}$

(*c*) $\sqrt{2}:\sqrt{4}:\sqrt{6}$

(*d*) 1 : 2 : 3

11. Change in kinetic energy of charge particle after every time period is

(*a*) $2qV$

(*b*) qV

(*c*) $3qV$

(*d*) None of these

12. If q/m for a charge particle is 10^6, frequency of applied AC is 10^6 Hz. Then applied magnetic field is

(*a*) 2π tesla

(*b*) π tesla

(*c*) 2 tesla

(*d*) None of these

13. Distance travelled in each time period are in the ratio of

(*a*) $\sqrt{1}+\sqrt{3}:\sqrt{5}+\sqrt{7}:\sqrt{9}+\sqrt{11}$

(*b*) $\sqrt{2}+\sqrt{3}:\sqrt{4}+\sqrt{5}:\sqrt{6}+\sqrt{7}$

(*c*) $\sqrt{1}:\sqrt{2}:\sqrt{3}$

(*d*) $\sqrt{2}:\sqrt{3}:\sqrt{4}$

14. For a given charge particle a cyclotron can be "tuned" by

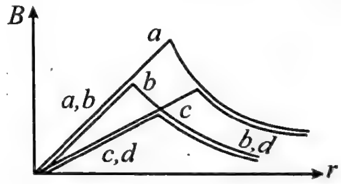
(*a*) Changing applied A.C. voltage only.

(*b*) Changing applied A.C. voltage and magnetic field both.

(*c*) Changing applied magnetic field only.

(*d*) By changing frequency of applied A.C.

Comprehension(Q. 15 to 17): Curves in the graph shown give, as functions of radial distance r (from the axis), the magnitude B of the magnetic field (due to individual wire) inside an outside four long wires a, b, c and d, carrying currents that are uniformly distributed across the cross sections of the wires. Overlapping portions of the plots are indicated by double labels. All curves start from the origin.



15. Which wire has the greatest radius?

(*a*) a (*b*) b

(*c*) c (*d*) d

16. Which wire has the greatest magnitude of the magnetic field on the surface?

(*a*) a (*b*) b

(*c*) c (*d*) d

17. The current density in wire a is

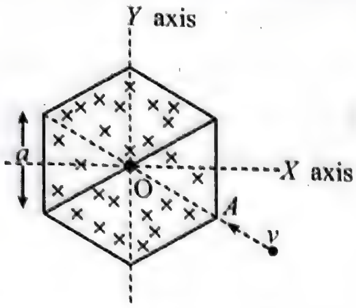
(*a*) Greater than in wire c.

(*b*) Less than in wire c.

(*c*) Equal to that in wire c.

(*d*) Not comparable to that of in wire c due to lack of information.

Comprehension(Q. 18 to 24): A uniform and transverse magnetic field exists into a regular hexagonal region as shown in figure. A charged particle 'q' is thrown into the magnetic field with speed along line OA.



18. The time spent by charged particle in magnetic field is

(a) $\frac{\pi m}{qB}$ (b) $\frac{2\pi m}{qB}$

(c) $\frac{\pi m}{3qB}$ (d) $\frac{\pi m}{\sqrt{3}qB}$

19. The derivation in the path of charged particle is

(a) 30° (b) 60°

(c) 90° (d) 120°

20. The magnitude of change in velocity and magnitude of average acceleration during the time charge remains inside magnetic field.

(a) Zero, $\frac{qvB}{m}$ (b) $V, \frac{3qvB}{\pi m}$

(c) $\sqrt{3}V, \frac{3qvB}{m}$ (d) $3V, \frac{\sqrt{3}qvB}{\pi m}$

21. Find the displacement and average velocity during the time it remains in magnetic field

(a) $a\sqrt{3}, \frac{qBa}{\pi m}$

(b) $a\sqrt{3}, 3\sqrt{3}\frac{qBa}{\pi m}$

(c) $\frac{a}{\sqrt{3}}, \frac{qBa}{\pi m}$

(d) $\frac{a}{\sqrt{3}}, \frac{3\sqrt{3}\,qBa}{\pi m}$

22. Find angular momentum of charged particle about centre of curvature of trajectory

(a) mva (b) $\frac{mva}{\sqrt{3}}$

(c) $mva\sqrt{3}$ (d) $\frac{mva}{3}$

23. Find angular momentum of charged particle about centre of hexagon when deviation becomes $\frac{\pi}{6}$.

(a) $mva(\sqrt{3}-1)$ (b) $mav(2-\sqrt{3})$

(c) $mva(\sqrt{3})$ (d) $mva(\sqrt{2}-1)$

24. According to the given coordinate system in the figure, find the equation of trajectory of the charged particle during the time it remains in magnetic field

(a) $(x-2a)^2+(y+2a)^2=3a^2$

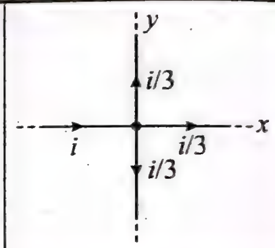
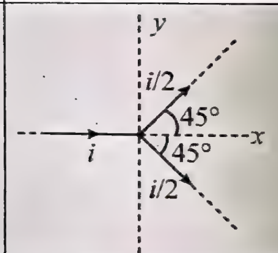
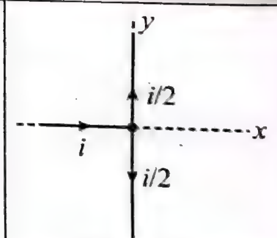
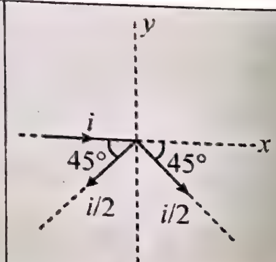
(b) $(x+2a)^2+(y+2a)^2=2a^2$

(c) $x^2+(y+2a)^2=2a^2$

(d) $x^2+(y+2a)^2=3a^2$

MATCH THE COLUMN TYPE QUESTIONS

25. Column-II gives four situations in which three (in q, r, s) and four (in p) semi infinite current carrying wires are placed in xy-plane as shown. The magnitude and direction of current is shown in each figure. Column-I gives statements regarding the x and y components of magnetic field at a point P whose coordinates are $P(0, 0, d)$. Match the statements in Column-I with the corresponding figures in Column-II.

Column-I		Column-II	
A.	The x component of magnetic field at point P is zero in	p.	
B.	The z component of magnetic field at point P is zero in	q.	
C.	The magnitude of magnetic field at point P is $\frac{\mu_0 i}{4\pi d}$ in	r.	
D.	The magnitude of magnetic field at point P is less than $\frac{\mu_0 i}{2\pi d}$ in	s.	

(a) A-(p,q,r) ; B-(p,q) ; C-(q,r) ; D-(p,q,r)

(b) A-(p,q,r) ; B-(p,q,r,s) ; C-(r) ; D-(p,q,r,s)

(c) A-(p,q) ; B-(q,r,s) ; C-(r) ; D-(p,r,s)

(d) A-(p,q,s) ; B-(q,r,s) ; C-(r) ; D-(p,q,r)

26. There are four situations given in Column-I involving a magnetic dipole of dipole moment $\vec{\mu}$ placed in uniform external magnetic field $\vec{B}$. Column-II gives corresponding results. Match the situations in Column-I with the corresponding results in Column-II.

	Column-I		Column-II
A.	Magnetic dipole moment $\vec{\mu}$ is parallel to uniform external magnetic field $\vec{B}$ (angle between both vectors is zero)	p.	Force on dipole is zero
B.	Magnetic dipole moment $\vec{\mu}$, is perpendicular to uniform external magnetic field $\vec{B}$	q.	Torque on dipole is zero
C.	Angle between magnetic dipole moment $\vec{\mu}$ and uniform external magnetic field $\vec{B}$ is acute	r.	Magnitude of torque is (μB)
D.	Angle between magnetic dipole moment $\vec{\mu}$ and uniform external magnetic field $\vec{B}$ is 180°.	s.	Potential energy of dipole due to external magnetic field is (μB)

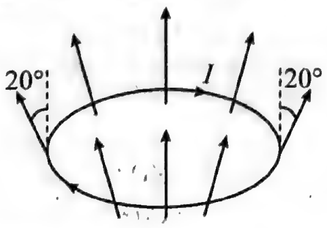
(*a*) A-(p,q) ; B-(r,s) ; C-(p) ; D-(p,q,r)
(*b*) A-(p) ; B-(p,r) ; C-(r) ; D-(p,q)
(*c*) A-(p,q) ; B-(p,r) ; C-(p) ; D-(p,q,s)
(*d*) A-(q,r) ; B-(r) ; C-(p) ; D-(q,r)

NUMERICAL TYPE QUESTIONS

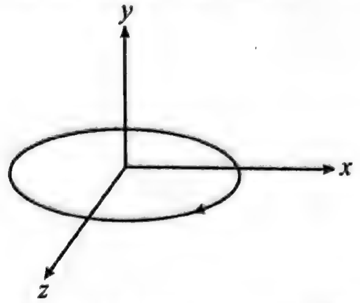
27. A charge $q = -4\mu C$ has an instantaneous velocity $\vec{v} = (2 \times 10^6\hat{i} - 3 \times 10^6\hat{j} + 10^6\hat{k})$ m/s in a uniform field = $(2 \times 10^{-2}\hat{i} + 5 \times 10^{-2}\hat{j} - 3 \times 10^{-2}\hat{k})$ T. What is the magnitude of x component of force on the charge in N?

28. An electron accelerated by a potential difference $V = 1.0$ kV moves in a uniform magnetic field at an angle $\alpha = 30°$ to the vector B whose modulus is $B = 29$mT. Find the pitch of the helical trajectory of the electron in mm.

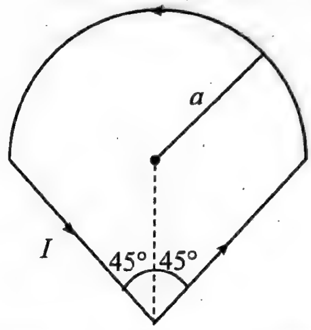
29. A super conducting ring has a radius of 1.4 cm and a mass of 30g. The ring carries a constant current I and is placed in a 0.5 T magnetic field with field lines that are tilted at a 20° angle, outward from the vertical at every location around the ring. What must the current I in Ampere be for the ring to float in the magnetic field?
[Given sin20° = 0.34 ; cos20° = 0.94]



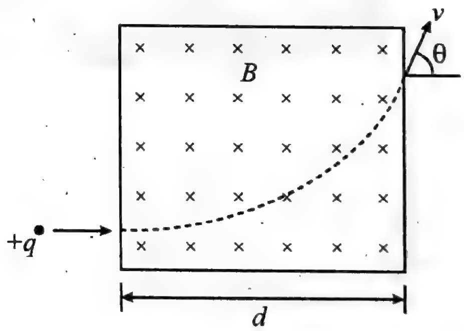
30. A coil of radius 25 cm has 15 turns and lies in the x-z plane. It carries a current of 2A, as in figure. Find magnitude of torque o the col for $\vec{B} = 0.2\hat{i}$ T in Nm.



31. Two perpendicular straight wires join the ends of a semicircular loop of radius a, as shown in the figure. If the current is I, the resultant field at the centre of the circular section is given by $x \times 10^{-7}\,\frac{I}{a}$ then x is



32. A proton accelerated by a potential difference $V = 500$ kV flies through a uniform transverse magnetic field with induction $B = 0.51$ T. The field occupies a region of space $d = 10$ cm in thickness. Find the angle θ in degree through which the proton deviates from the initial direction of its motion.

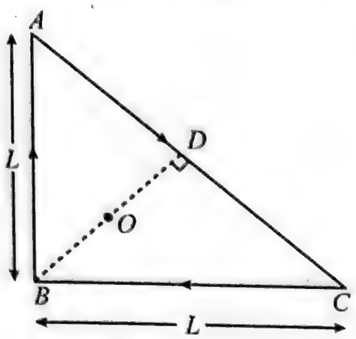


33. The magnetic field existing in a region is given by $\vec{B} = B_0\left(1+\frac{x}{l}\right)\hat{k}$. A square loop of side l and carrying a current I, is placed with its sides parallel to the x and y axes. The magnitude of the net magnetic force experienced by the loop is kB_0Il, then k is

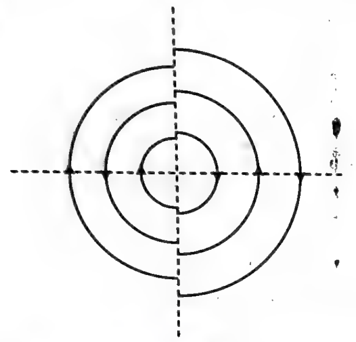
34. A current $I = 10$A flows in a ring of radius $r_0 = 15$ cm made of a very thin wire. The tensile strength of the wire is equal to $T = 1.5$ N. The ring is placed in a magnetic field which is perpendicular to the plane of the ring so that the forces tend to break the ring. Find B in Tesla at which the ring is broken.

SUBJECTIVE TYPE QUESTIONS

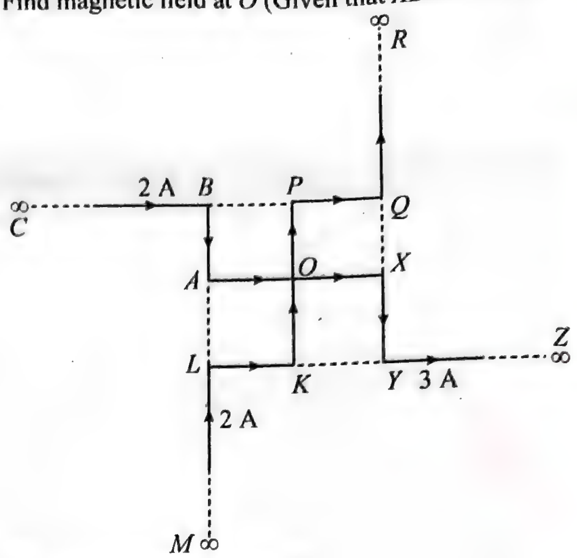
35. In the given figure ABC is a right angled triangle shape wire carrying current I. Here $OB = OD$ then find the net magnetic field at O.



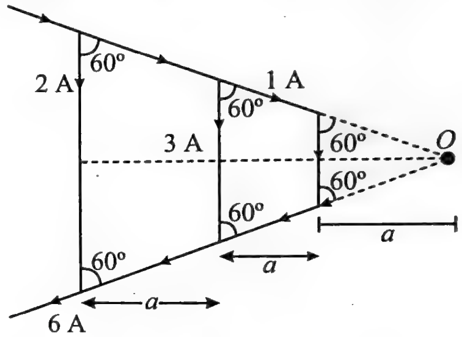
36. In the given figure current in each element is I. Radius of each semicircular element is double of preceding semi circular element. There are infinite number of repetitions like this. Find net magnetic field at origin. (Smallest semicircle has radius R)



37. Find magnetic field at O (Given that $AB = OA = a$)



38. Find net magnetic field at O.



Exercise-4 (Past Year Questions)

JEE MAIN

1. The dipole moment of a circular loop carrying a current I is m and the magnetic field at the centre of the loop is B_1. When the dipole moment is doubled by keeping the current constant, the magnetic field at the centre of the loop is B_2. The ratio $\frac{B_1}{B_2}$ is **(2018)**

(*a*) $\sqrt{3}$ (*b*) $\sqrt{2}$

(*c*) $\frac{1}{\sqrt{2}}$ (*d*) 2

2. A particle having the same charge as of electron moves in a circular path of radius 0.5 cm under the influence of a magnetic field of 0.5 T. If an electric field of 100 V/m makes it to move in a straight path, then the mass of the particle is (given charge of electron = 1.6×10^{-19}C) **(2019)**

(*a*) 9.1×10^{-31} kg (*b*) 1.6×10^{-27} kg

(*c*) 1.6×10^{-19} kg (*d*) 2.0×10^{-24} kg

3. One of the two identical conducting wires of length L is bent in the form of a circular loop and the other one into a circular coil of N identical turns. If the same current is passed in both, the ratio of the magnetic field at the centre of the loop (B_L) to that at the centre of the coil (B_C), i.e. $\frac{B_L}{B_C}$ will be **(2019)**

(*a*) N (*b*) $\frac{1}{N}$

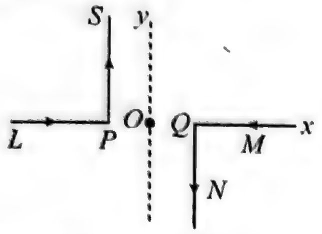
(*c*) N^2 (*d*) $\frac{1}{N^2}$

4. An insulating thin rod of length ℓ has a linear charge density $\rho(x) = \rho_0 \frac{x}{\ell}$ on it. The rod is rotated about an axis passing through the origin ($x = 0$) and perpendicular to the rod. If the rod makes n rotations per second, then the time averaged magnetic moment of the rod is **(2019)**

(*a*) $\pi n \rho_0 \ell^3$ (*b*) $\frac{\pi}{3} n \rho_0 \ell^3$

(*c*) $\frac{\pi}{4} n \rho_0 \ell^3$ (*d*) $n \rho_0 \ell^3$

5. As shown in the figure, two infinitely long, identical wires are bent by 90° and placed in such a way that the segments LP and QM are along the x-axis, while segments PS and QN are parallel to the y-axis. If $OP = OQ = 4$ cm, and the magnitude of the magnetic field at O is 10^{-4} T, and the two wires carry equal current (see figure), the magnitude of the current in each wire and the direction of the magnetic field at O will be ($\mu_0 = 4\pi \times 10^{-7}$ NA^{-2}) **(2019)**



(a) 20 A, perpendicular out of the page.
(b) 40 A, perpendicular out of the page.
(c) 20 A, perpendicular into the page.
(d) 40 A, perpendicular into the page.

6. A proton and an α-particle (with their masses in the ratio of 1 : 4 and charges in the ratio of 1:2) are accelerated from rest through a potential difference V. If a uniform magnetic field (B) is set up perpendicular to their velocities, the ratio of the radii $r_p : r_\alpha$ of the circular paths described by them will be **(2019)**

(a) $1:\sqrt{2}$ (b) $1:2$
(c) $1:3$ (d) $1:\sqrt{3}$

7. A moving coil galvanometer has a coil with 175 turns and area 1 cm^2. It uses a torsion band of torsion constant 10^{-6} N–m/rad. The coil is placed in a magnetic field B parallel to its plane. The coil deflects by 1° for a current of 1 mA. The value of B (in Tesla) is approximately **(2019)**

(a) 10^{-3} (b) 10^{-1}
(c) 10^{-4} (d) 10^{-2}

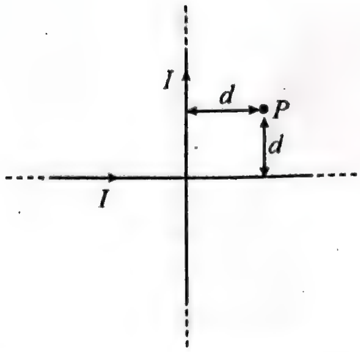
8. A circular coil having N turns and radius r carries a current I. It is held in the XZ plane in a magnetic field $B\hat{i}$. The torque on the coil due to the magnetic field is **(2019)**

(a) $B\pi r^2 IN$ (b) $\dfrac{Br^2 I}{\pi N}$
(c) Zero (d) $\dfrac{B\pi r^2 I}{N}$

9. The magnitude of the magnetic field at the center of an equilateral triangular loop of side 1 m which is carrying a current of 10 A is : [Take $\mu_0 = 4\pi \times 10^{-7}$ NA^{-2}] **(2019)**

(a) 18 μT (b) 3μT
(c) 1 μT (d) 9 μT

10. Two very long, straight and insulated wires are kept at 90° angle from each other in xy-plane as shown in the figure. These wires carry currents of equal magnitude I, whose directions are shown in the figure. The net magnetic field at point P will be **(2019)**

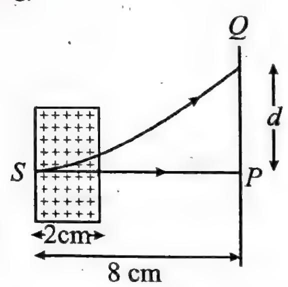


(a) Zero (b) $\dfrac{+\mu_0 I}{\pi d}(\hat{z})$
(c) $-\dfrac{\mu_0 I}{2\pi d}(\hat{x}+\hat{y})$ (d) $\dfrac{\mu_0 I}{2\pi d}(\hat{x}+\hat{y})$

11. A rectangular coil (dimension 5 cm × 2.5 cm) with 100 turns, carrying a current of 3 A in the clock-wise direction is kept centered at the origin and in the X-Z plane. A magnetic field of 1 T is applied along X-axis. If the coil is tilted through 45° about Z-axis, then the torque on the coil is **(2019)**

(a) 0.55 Nm (b) 0.27 Nm
(c) 0.38 Nm (d) 0.42 Nm

12. An electron, moving along the x-axis with an initial energy of 100 eV enters a region of magnetic field $\vec{B} = (1.5\times10^{-3}T)\hat{k}$ at S (See figure). The field extends between $x = 0$ and $x = 2$ cm. The electron is detected at the point Q on a screen placed 8 cm away from the point S. The distance d between P and Q (on the screen) is (Electron's charge $= 1.6 \times 10^{-19}$ C, mass of electron $= 9.1 \times 10^{-31}$ kg) **(2019)**

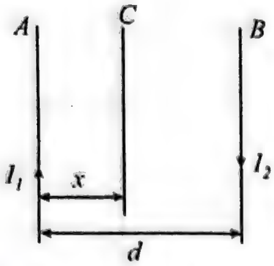


(a) 12.87 cm (b) 1.22 cm
(c) 11.65 cm (d) 2.25 cm

13. A proton, an electron, and a Helium nucleus, have the same energy. They are in circular orbits in a plane due to magnetic field perpendicular to the plane. Let r_p, r_e and r_{He} be their respective radii, then, **(2019)**

(a) $r_e > r_p > r_{He}$ (b) $r_e < r_p < r_{He}$
(c) $r_e < r_p = r_{He}$ (d) $r_e > r_p = r_{He}$

14. Two wires A and B are carrying currents I_1 and I_2 as shown in the figure. The separation between them is d. A third wire C carrying a current I is to be kept parallel to them at a distance x from A such that the net force acting on it is zero. The possible values of x are **(2019)**



(a) $x=\left(\frac{I_1}{I_1-I_2}\right)d$ and $x=\frac{I_2}{(I_1+I_2)}d$

(b) $x=\pm\frac{I_1 d}{(I_1-I_2)}$

(c) $x=\left(\frac{I_1}{I_1+I_2}\right)d$ and $x=\frac{I_2}{(I_1-I_2)}d$

(d) $x=\left(\frac{I_2}{I_1+I_2}\right)d$ and $x=\left(\frac{I_2}{I_1-I_2}\right)d$

15. A particle of mass m and charge q has an initial velocity $\vec{v}=v_0\hat{j}$. If an electric field $\vec{E}=E_0\hat{i}$ and magnetic field $\vec{B}=B_0\hat{i}$ act on the particle, its speed will double after a time **(2020)**

(a) $\frac{2mv_0}{qE_0}$ (b) $\frac{3mv_0}{qE_0}$

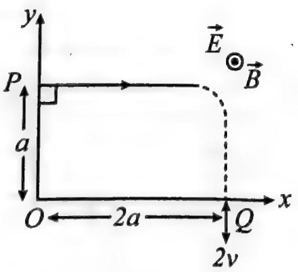
(c) $\frac{\sqrt{2}mv_0}{qE_0}$ (d) $\frac{\sqrt{3}mv_0}{qE_0}$

16. Proton with kinetic energy of 1 MeV moves from south to north. It gets an acceleration of 10^{12}m/s^2 by an applied magnetic field (west to east). The value of magnetic field. (Rest mass of proton is 1.6×10^{-27} kg) **(2020)**

(a) 7.1 mT (b) 71 mT

(c) 0.71 mT (d) 0.071 mT

17. A charged particle of mass 'm' and charge 'q' moving under the influence of uniform electric field $E\vec{i}$ and uniform magnetic field $B\hat{k}$ follows a trajectory from point P to Q as shown in figure. The velocities at P and Q are respectively, $v\hat{i}$ and $-2v\hat{j}$. Then which of the following statements (A, B, C, D) are the correct ? (Trajectory shown is schematic and not to scale)



A. $E=\frac{3}{4}\left(\frac{mv^2}{qa}\right)$

B. Rate of work done by the electric field at P is $\frac{3}{4}\left(\frac{mv^3}{a}\right)$

C. Rate of work done by both the fields at Q is zero

D. The difference between the magnitude of angular momentum of the particle at P and Q is $2mav$. **(2020)**

(a) A, B, C (b) A, B, C, D

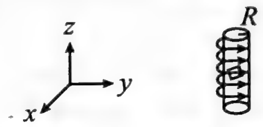
(c) A, C, D (d) B, C, D

18. A long, straight wire of radius a carries a current distributed uniformly over its cross-section. The ratio of the magnetic fields due to the wire at distance $\frac{a}{3}$ and $2a$, respectively from the axis of the wire is **(2020)**

(a) $\frac{1}{2}$ (b) 2

(c) $\frac{3}{2}$ (d) $\frac{2}{3}$

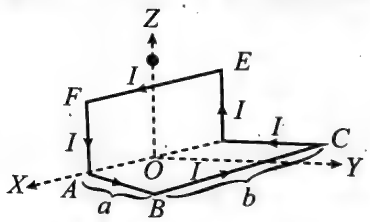
19. An electron gun is placed inside a long solenoid of radius R on its axis. The solenoid has n turns/length and carries a current I. The electron gun shoots an electron along the radius of the solenoid with speed v. If the electron does not hit the surface of the solenoid, maximum possible value of v is (all symbols have their standard meaning) **(2020)**



(a) $\frac{e\mu_0 nIR}{2m}$ (b) $\frac{e\mu_0 nIR}{m}$

(c) $\frac{2e\mu_0 nIR}{m}$ (d) $\frac{e\mu_0 nIR}{4m}$

20. A wire carrying current I is bent in the shape $ABCDEFA$ as shown, where rectangle $ABCDA$ and $ADEFA$ are perpendicular to each other. If the sides of the rectangles are of lengths a and b, then the magnitude and direction of magnetic moment of the loop $ABCDEFA$ is **(2020)**



(a) abI, along $\left(\frac{\hat{j}}{\sqrt{5}}+\frac{2\hat{k}}{\sqrt{5}}\right)$

(b) $\sqrt{2}\,abI$, along $\left(\frac{\hat{j}}{\sqrt{2}}+\frac{\hat{k}}{\sqrt{2}}\right)$

(c) abI, along $\left(\frac{\hat{j}}{\sqrt{2}}+\frac{\hat{k}}{\sqrt{2}}\right)$

(d) $\sqrt{2}\,abI$, along $\left(\frac{\hat{j}}{\sqrt{5}}+\frac{2\hat{k}}{\sqrt{5}}\right)$

21. A beam of protons with speed 4×10^5 m/s enters a uniform magnetic field of 0.3 T at an angle of 60° to the magnetic field. The pitch of the resulting helical path of protons is

close to (Mass of the proton = 1.67×10^{-27} kg, charge of the proton = 1.69×10^{-19} C) **(2020)**

(*a*) 2 cm (*b*) 12 cm

(*c*) 5 cm (*d*) 4 cm

22. A galvanometer coil has 500 turns and each turn has an average area of 3×10^{-4} m^2. If a torque of 1.5 Nm is required to keep this coil parallel to a magnetic field when a current of 0.5 A is flowing through it, the strength of the field (in T) is ________. **(2020)**

23. A charged particle carrying charge 1 μC is moving with velocity $(2\hat{i}+3\hat{j}+4\hat{k})\text{ms}^{-1}$. If an external magnetic field of $(5\hat{i}+3\hat{j}-6\hat{k})\times10^{-3}$ T exists in the region where the particle is moving then the force on the particle is $\vec{F}\times10^{-9}$ N. The vector $\vec{F}$ is **(2020)**

(*a*) $-3.0\hat{i}+3.2\hat{j}-0.9\hat{k}$ (*b*) $-300\hat{i}+320\hat{j}-90\hat{k}$

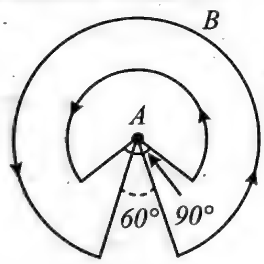
(*c*) $-0.30\hat{i}+0.32\hat{j}-0.09\hat{k}$ (*d*) $-30\hat{i}+32\hat{j}-9\hat{k}$

24. A circular coil has moment of inertia 0.8 kg m^2 around any diameter and is carrying current to produce a magnetic moment of 20 Am^2. The coil is kept initially in a vertical position and it can rotate freely around a horizontal diameter. When a uniform magnetic field of 4 T is applied along the vertical, it starts rotating around its horizontal diameter. The angular speed the coil acquires after rotating by 60° will be **(2020)**

(*a*) 10 rad s^{-1} (*b*) 10π rad s^{-1}

(*c*) 20 rad s^{-1} (*d*) 20π rad s^{-1}

25. A wire *A*, bent in the shape of an arc of a circle, carrying a current of 2 A and having radius 2 cm and another wire *B*, also bent in the shape of arc of a circle, carrying a current of 3 A and having radius of 4 cm, are placed as shown in the figure. The ratio of the magnetic fields due to the wires *A* and *B* at the common centre *O* is **(2020)**



(*a*) 2 : 5 (*b*) 6 : 5

(*c*) 4 : 6 (*d*) 6 : 4

26. A charged particle going around in a circle can be considered to be a current loop. A particle of mass *m* carrying charge *q* is moving in a plane with speed *v* under the influence of magnetic field $\vec{B}$. The magnetic moment of this moving particle is **(2020)**

(*a*) $-\dfrac{mv^2\vec{B}}{2B^2}$ (*b*) $\dfrac{mv^2\vec{B}}{2B^2}$

(*c*) $-\dfrac{mv^2\vec{B}}{2\pi B^2}$ (*d*) $-\dfrac{mv^2\vec{B}}{B^2}$

27. A particle moving in the *xy* plane experiences a velocity dependent force $\vec{F}=k(v_y\hat{i}+v_x\hat{j})$, where v_x and v_y are the *x* and *y* components of its velocity $\vec{v}$. If $\vec{a}$ is the acceleration of the particle, then which of the following statements is true for the particle? **(2020)**

(*a*) Quantity $\vec{v}\cdot\vec{a}$ is constant in time.

(*b*) Kinetic energy of particle is constant in time.

(*c*) Quantity $\vec{v}\times\vec{a}$ is constant in time.

(*d*) $\vec{F}$ arises due to a magnetic field.

28. A square loop of side 2*a* and carrying current *I* is kept in *xz* plane with its centre at origin. A long wire carrying the same current *I* is placed parallel to *z*-axis and passing through point (0, *b*, 0), (*b* >> *a*). The magnitude of torque on the loop about *z*-axis will be **(2020)**

(*a*) $\dfrac{\mu_0 I^2 a^2}{2\pi b}$ (*b*) $\dfrac{2\mu_0 I^2 a^2 b}{\pi(a^2+b^2)}$

(*c*) $\dfrac{\mu_0 I^2 a^2 b}{2\pi(a^2+b^2)}$ (*d*) $\dfrac{2\mu_0 I^2 a^2}{\pi b}$

29. An electron is moving along +*x* direction with a velocity of 6×10^6 ms^{-1}. It enters a region of uniform electric field of 300 V/cm pointing along +*y* direction. The magnitude and direction of the magnetic field set up in this region such that the electron keeps moving along the *x* direction will be **(2020)**

(*a*) 5×10^{-3} T, along + *z* direction.

(*b*) 5×10^{-3} T, along – *z* direction.

(*c*) 3×10^{-4} T, along + *z* direction.

(*d*) 3×10^{-4} T, along – *z* direction.

30. A loop of flexible wire of irregular shape carrying current is placed in an external magnetic field. Identify the effect of the field on the wire **(2021)**

(*a*) Loop assumes circular shape with its plane normal to the field.

(*b*) Loop assumes circular shape with its plane parallel to the field.

(*c*) Wire gets stretched to become straight.

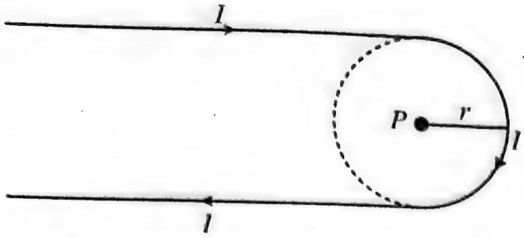
(*d*) Shape of the loop remains unchanged.

31. A coil having *N* turns is wound tightly in the form of a spiral with inner and outer radii *a* and *b* respectively. Find the magnetic field at centre, when a current *I* passes through coil. **(2021)**

(*a*) $\dfrac{\mu_0 I}{8}\left[\dfrac{a+b}{a-b}\right]$ (*b*) $\dfrac{\mu_0 I}{4(a-b)}\left[\dfrac{1}{a}-\dfrac{1}{b}\right]$

(*c*) $\dfrac{\mu_0 I}{8}\left(\dfrac{a-b}{a+b}\right)$ (*d*) $\dfrac{\mu_0 IN}{2(b-a)}\log_e\left(\dfrac{b}{a}\right)$

32. A hairpin like shape as shown in figure is made by bending a long current carrying wire. What is the magnitude of a magnetic field at point *P* which lies on the centre of the semicircle? **(2021)**



(a) $\frac{\mu_0 I}{2\pi r}(2-\pi)$ (b) $\frac{\mu_0 I}{4\pi r}(2-\pi)$

(c) $\frac{\mu_0 I}{2\pi r}(2+\pi)$ (d) $\frac{\mu_0 I}{4\pi r}(2+\pi)$

33. A coil in the shape of an equilateral triangle of side 10 cm lies in a vertical plane between the pole pieces of permanent magnet producing a horizontal magnetic field 20 mT. The torque acting on the coil when a current of 0.2 A is passed through it and its plane becomes parallel to the magnetic field will be $\sqrt{x}\times 10^{-5}$ N m. The value of x is **(2021)**

34. A proton, a deuteron and an α-particle are moving with same momentum in a uniform magnetic field. The ratio of magnetic forces acting on them is ________ and their speed is ________, in the ratio. **(2021)**

(a) 4 : 2 : 1 and 2 : 1 : 1 (b) 2 : 1 : 1 and 4 : 2 : 1

(c) 1 : 2 : 4 and 1 : 1 : 2 (d) 1 : 2 : 4 and 2 : 1 : 1

35. The fractional change in the magnetic field intensity at a distance 'r' from centre on the axis of current carrying coil of radius 'a' to the magnetic field intensity at the centre of the same coil is (Take $r < a$). **(2021)**

(a) $\frac{2}{3}\frac{a^2}{r^2}$ (b) $\frac{3}{2}\frac{a^2}{r^2}$

(c) $\frac{3}{2}\frac{r^2}{a^2}$ (d) $\frac{2}{3}\frac{r^2}{a^2}$

36. Given below are two statements: One is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): In uniform magnetic field, speed and energy remains the same for a moving charged particle.

Reason (R): Moving charged particle experiences magnetic force perpendicular to its direction of motion. **(2022)**

(a) Both (A) and (R) are true and (R) is the correct explanation of (A).

(b) Both (A) and (R) are true but (R) is NOT the correct explanation of (A).

(c) (A) is true but (R) is false.

(d) (A) is false but (R) is true.

37. The magnetic field at the centre of a circular coil of radius r, due to current I flowing through it, is B. The magnetic field at a point along the axis at a distance $r/2$ from the centre is **(2022)**

(a) $B/2$ (b) $2B$

(c) $\left(\frac{2}{\sqrt{5}}\right)^3 B$ (d) $\left(\frac{2}{\sqrt{3}}\right)^3 B$

38. Two charged particles, having same kinetic energy, are allowed to pass through a uniform magnetic field perpendicular to the direction of motion. If the ratio of radii of their circular paths is 6 : 5 and their respective masses ratio is 9 : 4, then, the ratio of their charges will be **(2022)**

(a) 8 : 5 (b) 5 : 4 (c) 5 : 3 (d) 8 : 7

39. A charge particle is moving in a uniform magnetic field $(2\hat{i}+3\hat{j})$T. If it has an acceleration of $(\alpha\hat{i}-4\hat{j})$m/s^2, then the value of α is **(2022)**

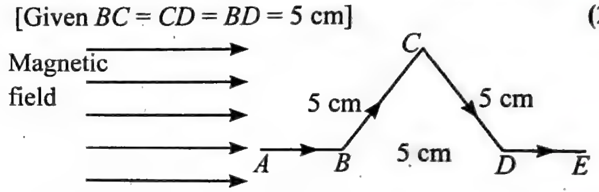
(a) 3 (b) 6 (c) 12 (d) 2

40. A cyclotron is used to accelerate protons. If the operating magnetic field is 1.0 T and the radius of the cyclotron 'dees' is 60 cm, the kinetic energy of the accelerated protons in MeV will be [Use $m_p = 1.6\times10^{-27}$ kg, $e = 1.6\times10^{-19}$C] **(2022)**

(a) 12 (b) 18 (c) 16 (d) 32

41. A triangular shaped wire carrying 10 A current is placed in a uniform magnetic field of 0.5 T, as shown in figure. The magnetic force on segment CD is

[Given $BC = CD = BD = 5$ cm] **(2022)**



(a) 0.126 N (b) 0.312 N (c) 0.216 N (d) 0.245 N

JEE ADVANCED

42. Consider the motion of a positive point charge in a region where there are simultaneous uniform electric and magnetic fields $\vec{E}=E_0\hat{j}$ and $\vec{B}=B_0\hat{j}$. At time $t=0$, this charge has velocity $\vec{v}$ in the x-y plane, making an angle θ with x-axis. Which of the following option(s) is(are) correct for time $t>0$? **(2012)**

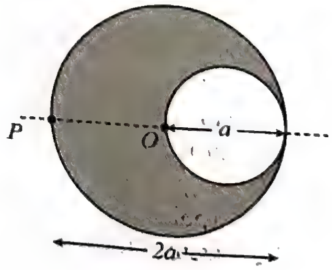
(a) If θ = 0°, the charge moves in a circular path in the x-z plane.

(b) If θ = 0°, the charge undergoes helical motion with constant pitch along the y-axis.

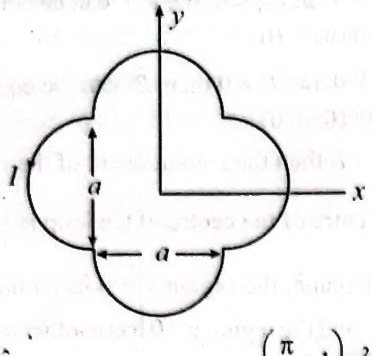
(c) If θ = 10°, the charge undergoes helical motion with its pitch increasing with time, along the y-axis.

(d) If θ = 90°, the charge undergoes linear but accelerated motion along the y-axis.

43. A cylindrical cavity of diameter a exists inside a cylinder of diameter $2a$ shown in the figure. Both the cylinder and the cavity are infinitely long. A uniform current density J flows along the length. If the magnitude of the magnetic field at the point P is given by $\frac{N}{12}\mu_0 a J$, then the value of N is **(2012)**



44. A loop carrying current I lies in the x-y plane as shown in the figure. The unit vector $\hat{k}$ is coming out of the plane of the paper. The magnetic moment of the current loop is **(2012)**

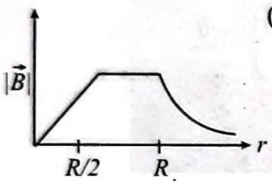


(a) $a^2 I\hat{k}$ (b) $\left(\frac{\pi}{2}+1\right)a^2 I\hat{k}$

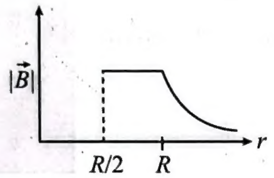
(c) $-\left(\frac{\pi}{2}+1\right)a^2 I\hat{k}$ (d) $(2\pi+1)a^2 I\hat{k}$

45. An infinitely long hollow conducting cylinder with inner radius $R/2$ and outer radius R carries a uniform current density along is length. The magnitude of the magnetic field, $|\vec{B}|$ as a function of the radial distance r from the axis is best represented by **(2012)**

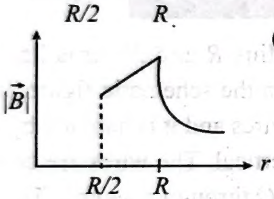
(a)



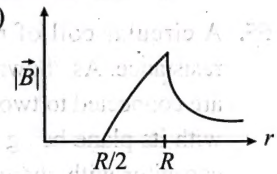
(b)



(c)



(d)



46. A particle of mass M and positive charge Q, moving with a constant velocity $\vec{u}_1 = 4\hat{i}\ \mathrm{ms^{-1}}$, enters a region of uniform static magnetic field normal to the x-y plane. The region of the magnetic field extends from $x = 0$ to $x = L$ for all values of y. After passing through this region, the particle emerges on the other side after 10 milliseconds with a velocity $\vec{u}_2 = 2\left(\sqrt{3}\,\hat{i}+\hat{j}\right)\mathrm{ms^{-1}}$. The correct statement(s) is (are) **(2013)**

(a) The direction of the magnetic field is $-z$ direction

(b) The direction of the magnetic field is $+z$ direction

(c) The magnitude of the magnetic field $\frac{50\pi M}{3Q}$ units

(d) The magnitude of the magnetic field is $\frac{100\pi M}{3Q}$ units

47. A steady current I flows along an infinitely long hollow cylindrical conductor of radius R. This cylinder is placed coaxially inside an infinite solenoid of radius $2R$. The solenoid has n turns per unit length and carries a steady current I. Consider a point P at a distance r from the common axis. The correct statement(s) is (are) **(2013)**

(a) In the region $0 < r < R$, the magnetic field is non–zero.

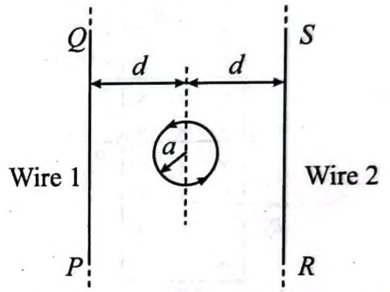
(b) In the region $R < r < 2R$, the magnetic field is along the common axis.

(c) In the region $R < r < 2R$, the magnetic field is tangential to the circle of radius r, centered on the axis.

(d) In the region $r > 2R$, the magnetic field is non–zero.

48. Two parallel wires in the plane of the paper are distance x_0 apart. A point charge is moving with speed u between the wires in the same plane at a distance x_1 from one of the wires. When the wires carry current of magnitude I in the same direction, the radius of curvature of the path of the point charge is R_1. In contrast, if the currents I in the two wires have direction opposite to each other, the radius of curvature of the path is R_2. If $\frac{x_0}{x_1} = 3$, the value of $\frac{R_1}{R_2}$ is **(2014)**

Paragraph for Questions 49 to 50: The figure shows a circular loop of radius a with two long parallel wires (numbered 1 and 2) all in the plane of the paper. The distance of each wire from the centre of the loop is d. The loop and the wires are carrying the same current I. The current in the loop is in the counter clockwise directon if seen from above. **(2014)**



49. When $d \approx a$ but wires are not touching the loop, it is found that the net magnetic filed on the axis of the loop is zero at a height h above the loop. In that case **(2014)**

(a) Current in wire 1 and wire 2 is the direction PQ and RS, respectively and $h \approx a$

(b) Current in wire 1 and wire 2 is the direction PQ and SR, respectively and $h \approx a$

(c) Current in wire 1 and wire 2 is the direction PQ and SR, respectively and $h \approx 1.2a$

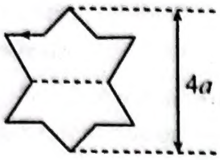
(d) Current in wire 1 and wire 2 is the direction PQ and RS, respectively and $h \approx 1.2a$

50. Consider $d >> a$, and the loop is rotated about its diameter parallel to the wires by 30° from the position shown in the figure. If the currents in the wires are in the opposite directions, the torque on the loop at its new position will be (assume that the net field due to the wires is constant over the loop) **(2014)**

(a) $\frac{\mu_0 I^2 a^2}{d}$ (b) $\frac{\mu_0 I^2 a^2}{2d}$

(c) $\frac{\sqrt{3}\mu_0 I^2 a^2}{d}$ (d) $\frac{\sqrt{3}\mu_0 I^2 a^2}{2d}$

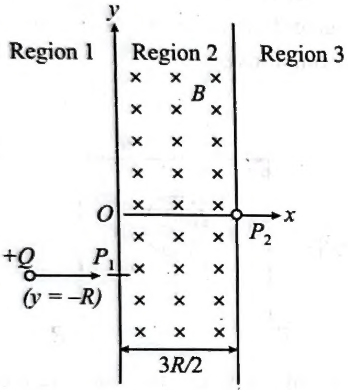
51. A symmetric star shaped conducting wire loop is carrying a steady state current I as shown in the figure. The distance between the diametrically opposite vertices of the star is $4a$. The magnitude of the magnetic field at the center of the loop is **(2017)**



(a) $\frac{\mu_0 I}{4\pi a}6\left[\sqrt{3}-1\right]$ (b) $\frac{\mu_0 I}{4\pi a}6\left[\sqrt{3}+1\right]$

(c) $\frac{\mu_0 I}{4\pi a}3\left[2+\sqrt{3}\right]$ (d) $\frac{\mu_0 I}{4\pi a}3\left[\sqrt{3}-1\right]$

52. A uniform magnetic field B exists in the region between $x = 0$ and $x = \frac{3R}{2}$ (region 2 in the figure) pointing normally into the plane of the paper. A particle with charge $+Q$ and momentum p directed along x-axis enters region 2 from region 1 at point P_1 ($y = -R$). Which of the following option(s) is/are correct? **(2017)**



(a) When the particle re-enters region 1 through the longest possible path in region 2, the magnitude of the change in its linear momentum between P_1 and the farthest point from y-axis is $p/\sqrt{2}$.

(b) For a fixed B, particles of same charge Q and same velocity v, the distance between the point P_1 and the point of re-entry into region 1 is inversely proportional to the mass of the particle.

(c) For $B = \frac{8}{13}\frac{p}{QR}$, the particle will enter region 3 through the point P_2 on x-axis.

(d) For $B > \frac{2}{3}\frac{p}{QR}$, the particle will re-enter region 1.

53. Two infinitely long straight wires lie in the xy-plane along the lines $x = \pm R$. The wire located at $x = +R$ carries a constant current I_1 and the wire located at $x = -R$ carries a constant current I_2. A circular loop of radius R is suspended with its centre at $(0, 0, \sqrt{3}R)$ and in a plane parallel to the xy-plane. This loop carries a constant I in the clockwise direction as seen from above the loop. The current in the wire is taken to be positive if it is in the $+\hat{j}$ direction. Which of the following statements regarding the magnetic field $\vec{B}$ is (are) true? **(2018)**

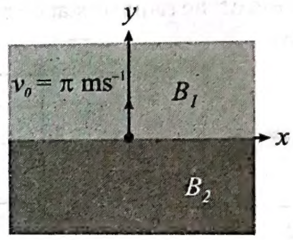
(a) If $I_1 = I_2$ then $\vec{B}$ cannot be equal to zero at the origin (0, 0, 0).

(b) If $I_1 > 0$ and $I_2 < 0$, then $\vec{B}$ can be equal to zero at the origin (0, 0, 0).

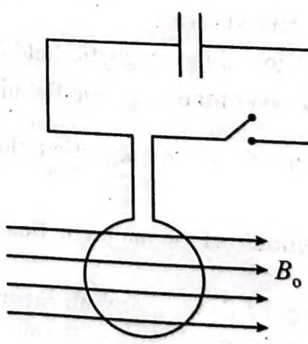
(c) If $I_1 > 0$ and $I_2 > 0$ then $\vec{B}$ can be equal to zero at the origin (0, 0, 0).

(d) If $I_1 = I_2$ then the z-component of the magnetic field at the centre of the centre of the loop is $\left(-\frac{\mu_0 I}{2R}\right)$.

54. In the x-y plane, the region $y > 0$ has a uniform magnetic field $B_1\hat{k}$ and the region $y < 0$ has another uniform magnetic field $B_2\hat{k}$. A positively charged particle is projected from the origin along the positive y-axis with speed $v_0 = \pi$ ms^{-1} at $t = 0$, as shown in the figure. Neglect gravity in this problem. Let $t = T$ be the time when the particle crosses the x-axis from below for the first time. If $B_2 = 4B_1$, the average speed of the particle, in ms^{-1}, along the x-axis in the time interval T is______. **(2018)**



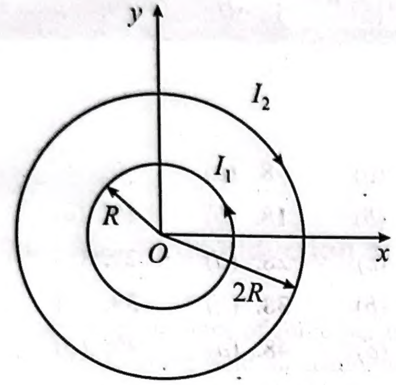
55. A circular coil of radius R and N turns has negligible resistance. As shown in the schematic figure, its two ends are connected to two wires and it is hanging by those wires with its plane being vertical. The wires are connected to a capacitor with charge Q through a switch. The coil is in a horizontal uniform magnetic field B parallel to the plane of the coil. When the switch is closed, the capacitor gets discharged through the coil in a very short time. By the time the capacitor is discharged fully, magnitude of the angular momentum gained by the coil will be (assume that the discharge time is so short that the coil has hardly rotated during this time) **(2020)**



(a) $\frac{\pi}{2}NQB_0R^2$ (b) πNQB_0R^2

(c) $2\pi NQB_0R^2$ (d) $4\pi NQB_0R^2$

56. Two concentric circular loops, one of radius R and the other of radius $2R$, lie in the xy-plane with the origin as their common center, as shown in the figure. The smaller loop carries current I_1 in the anti-clockwise direction and the larger loop carries current I_2 in the clockwise direction, with $I_2 > 2I_1$. $\vec{B}(x, y)$ denotes the magnetic field at a point (x, y) in the xy-plane. Which of the following statement(s) is(are) correct? **(2021)**



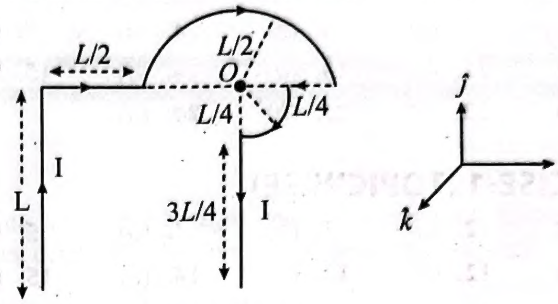
(a) $\vec{B}(x,y)$ is perpendicular to the xy-plane at any point in the plane.

(b) $|\vec{B}(x,y)|$ depends on x and y only through the radial distance $r=\sqrt{x^2+y^2}$.

(c) $|\vec{B}(x,y)|$ is non-zero at all points for $r < R$.

(d) $\vec{B}(x,y)$ points normally outward from the plane for all the points between the two loops.

57. Which one of the following options represents the magnetic field $\vec{B}$ at O due to the current flowing in the given wire segments lying on the xy plane? **(2022)**



(a) $\vec{B}=\frac{-\mu_o I}{L}\left(\frac{3}{2}+\frac{1}{4\sqrt{2}\pi}\right)\hat{k}$

(b) $\vec{B}=-\frac{\mu_o I}{L}\left(\frac{3}{2}+\frac{1}{2\sqrt{2}\pi}\right)\hat{k}$

(c) $\vec{B}=\frac{-\mu_o I}{L}\left(1+\frac{1}{4\sqrt{2}\pi}\right)\hat{k}$

(d) $\vec{B}=\frac{-\mu_o I}{L}\left(1+\frac{1}{4\pi}\right)\hat{k}$

ANSWER KEY

CONCEPT APPLICATION

1. (*c*)	**2.** (*c*)	**3.** (*c*)	**4.** (*a*)	**5.** (*d*)	**6.** (*a*)	**7.** (*b*)	**8.** (*b*)	**9.** (*b*)	**10.** (*a*)
11. (*c*)	**12.** (*a*)	**13.** (*d*)	**14.** (*d*)	**15.** (*d*)	**16.** (*d*)	**17.** (*d*)	**18.** (*b*)	**19.** (*a*)	**20.** (*c*)
21. (*b*)	**22.** (*c*)	**23.** (*b*)	**24.** (*d*)						

EXERCISE-1 (TOPICWISE)

1. (*d*)	**2.** (*d*)	**3.** (*b*)	**4.** (*a*)	**5.** (*d*)	**6.** (*b*)	**7.** (*a*)	**8.** (*b*)	**9.** (*c*)	**10.** (*b*)
11. (*b*)	**12.** (*d*)	**13.** (*b*)	**14.** (*c*)	**15.** (*a*)	**16.** (*c*)	**17.** (*b*)	**18.** (*b*)	**19.** (*a*)	**20.** (*d*)
21. (*b*)	**22.** (*b*)	**23.** (*d*)	**24.** (*c*)	**25.** (*d*)	**26.** (*b*)	**27.** (*c*)	**28.** (*d*)	**29.** (*b*)	**30.** (*d*)
31. (*b*)	**32.** (*b*)	**33.** (*a*)	**34.** (*b*)	**35.** (*a*)	**36.** (*d*)	**37.** (*b*)	**38.** (*d*)	**39.** (*c*)	**40.** (*a*)
41. (*b*)	**42.** (*a*)	**43.** (*c*)	**44.** (*c*)	**45.** (*b*)	**46.** (*b*)	**47.** (*d*)	**48.** (*a*)	**49.** (*d*)	

EXERCISE-2 (LEARNING PLUS)

1. (*c*)	**2.** (*a*)	**3.** (*d*)	**4.** (*b*)	**5.** (*a*)	**6.** (*d*)	**7.** (*a*)	**8.** (*d*)	**9.** (*b*)	**10.** (*b*)
11. (*a*)	**12.** (*a*)	**13.** (*d*)	**14.** (*a*)	**15.** (*c*)	**16.** (*b*)	**17.** (*a*)	**18.** (*b*)	**19.** (*b*)	**20.** (*b*)
21. (*c*)	**22.** (*a*)	**23.** (*c*)	**24.** (*a*)	**25.** (*b*)	**26.** (*d*)	**27.** (*d*)	**28.** (*a*)	**29.** (*b*)	**30.** (*a*)
31. (*c*)	**32.** (*b*)	**33.** (*c*)	**34.** (*a*)	**35.** (*d*)	**36.** (*b*)				

EXERCISE-3 (JEE ADVANCED LEVEL)

1. (*b,d*)	**2.** (*a,d*)	**3.** (*a,b,c,d*)	**4.** (*b,c,d*)	**5.** (*a,d*)	**6.** (*c,d*)	**7.** (*c,d*)	**8.** (*b,d*)	**9.** (*a,b,c*)	**10.** (*b*)
11. (*a*)	**12.** (*a*)	**13.** (*a*)	**14.** (*c*)	**15.** (*c*)	**16.** (*a*)	**17.** (*a*)	**18.** (*c*)	**19.** (*b*)	**20.** (*b*)
21. (*b*)	**22.** (*c*)	**23.** (*b*)	**24.** (*d*)	**25.** (*b*)	**26.** (*c*)	**27.** [0.16]	**28.** [20]	**29.** [20]	**30.** [1.18]
31. [7.14]	**32.** [30]	**33.** [1]	**34.** [1]	**35.** $(\sqrt{2}+\sqrt{10})\frac{\mu_0 I}{\pi L}$		**36.** $\frac{3\mu_0 I}{10r}$	**37.** (zero)	**38.** $\frac{19}{24}\frac{\mu_0}{\pi a}$	

EXERCISE-4 (PAST YEAR QUESTIONS)

JEE Main

1. (*b*)	**2.** (*d*)	**3.** (*d*)	**4.** (*c*)	**5.** (*c*)	**6.** (*a*)	**7.** (*a*)	**8.** (*a*)	**9.** (*a*)	**10.** (*a*)
11. (*b*)	**12.** (*a*)	**13.** (*c*)	**14.** (*b*)	**15.** (*d*)	**16.** (*c*)	**17.** (*a*)	**18.** (*d*)	**19.** (*a*)	**20.** (*b*)
21. (*d*)	**22.** [20]	**23.** (*d*)	**24.** (*a*)	**25.** (*b*)	**26.** (*a*)	**27.** (*c*)	**28.** (*d*)	**29.** (*a*)	**30.** (*a*)
31. (*d*)	**32.** (*d*)	**33.** [3]	**34.** (*c*)	**35.** (*c*)	**36.** (*a*)	**37.** (*c*)	**38.** (*b*)	**39.** (*b*)	**40.** (*c*)
41. (*c*)									

JEE Advanced

42. (*c,d*)	**43.** [5]	**44.** (*b*)	**45.** (*d*)	**46.** (*a,c*)	**47.** (*a,d*)	**48.** [3]	**49.** (*c*)	**50.** (*b*)	**51.** (*a*)
52. (*c,d*)	**53.** (*a,b,d*)	**54.** [2]	**55.** (*b*)	**56.** (*a,b*)	**57.** (*c*)				